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THE DISTRIBUTION OF INSECTS IN WESTERN NORTH AMERICA.*

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The fauna of the western part of North America has long been recognized as possessing many characteristics which have differentiated it from that found elsewhere in North America. This is particularly the case as regards the insects and Le Conte† as early as 1859 called attention to this. Other entomologists in more recent years have mentioned this fact and have cited many cases to show its peculiarity. The insect fauna as a whole, however, has not been studied in regard to this point. in the manner that it has merited.

Many years ago, I became interested in the subject and I have kept up my interest ever since and have availed myself of all opportunities that would enable me to gain information bearing upon it. I have studied all orders of insects to a certain extent, but most of my conclusions have been based upon a close study of the Coleoptera, particularly of the wingless and less mobile groups, such as certain of the *Carabidæ*, the *Silphidæ*, the *Tenebrionidæ*, the *Otiorychinæ*, and so forth. The other Coleoptera were used as checks as were in fact other groups of insects, and all other information bearing upon the subject of distribution in the territory under study, freely drawn upon for purposes of guidance.

* A revision of the paper read August 5, 1915, at the University of California, before the Summer Meeting of the Entomological Society of America.

† The Coleoptera of Kansas and Eastern New Mexico, by John L. LeConte, M. D., Smith. Miss. Contrib. to Knowledge, Vol. XI (1859).

As a result of these studies, I have come to believe that though the West Coast fauna is to a degree complex, it is yet made up of a definite number of elements which can be distinctly separated. The insect fauna as we now know it, has been derived from older faunas and these were either northern or southern in their origin. Each of these primary portions was in its turn composed of elements which had come into their present territory at different times and along different roads. Certain of these had remained pure and are at present restricted to definite areas, while others had either wholly or partially invaded regions already occupied by other elements and become mixed with them. These facts are of course in general in

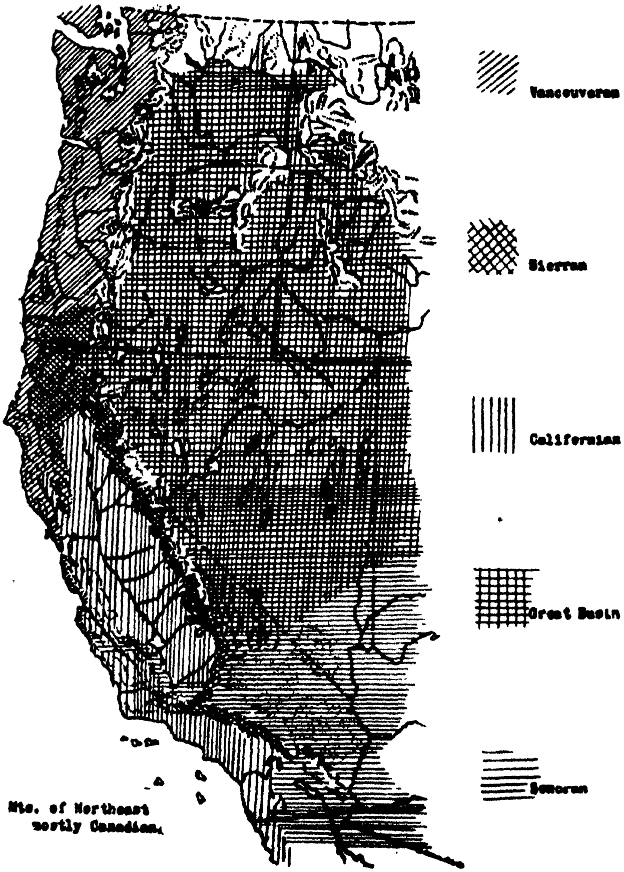

Fig. 1. Map showing the Faunal Areas of the Pacific States of North America.

keeping with those worked out by Merriam* and other mammalogists and ornithologists and substantiated by the botanists. Certain of the detailed results secured have, however, been found to be at variance with those found by others or to have previously not been worked out.

In general the insects which are considered to be of northern origin now occupy the northern and more mountainous portion of the territory. The greater portion of this, such as that including the lower levels of the Aleutian Islands, particularly the eastern ones, the southern margin of the Alaska Peninsula, southeastern Alaska, the western part of British Columbia as from the Selkirks west, Washington and Oregon west of the Cascade Mountains, and the wet and cool coastal strip of California, extending as far south as middle Monterey County, now supports a fauna which I have called the Vancouveran. The name Transitional as applied to this fauna, though generally used by previous workers, I consider misleading. The fauna is a pure one, in fact one of the purest in North America. It contains many peculiar groups of insects, some almost in their entirety, and is especially rich in such families as the *Carabidæ*, *Staphylinidæ*, *Elateridæ* and certain groups which are more or less closely associated with the coniferous forests. The following are good representatives: the genus Omus, the subgenus *Brennus* of *Scaphinotus*, the impunctate division of *Pterostichus*, *Zacotus*, *Metrius*, *Promecognathus* and the American representatives of *Trigonurus*. *Rosalia funebris* Mots. is also a characteristic member of this fauna, but it extends considerably beyond its confines. The fauna has existed in approximately its present territory from the Tertiary period and no doubt from well back in that period, being in fact a Tertiary fauna which has come down to us in a pure state. Many of the species that it contains have probably not changed during this long series of years but others have, some having become broken up into races which, becoming more and more isolated, have formed new species, subspecies, and so forth. As a result, the fauna is not the same throughout its extent. It gradually divides itself up into several subfaunas.

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* The Geographical Distribution of Life in North America with Special Reference to Mammalia, by C Hart Merriam, Proceed. Biol Soc. Wash Vol. VII, April 13, 1892.

The first of these occupies the following regions: the coastal belt of southeast Alaska and British Columbia with the adjacent islands, the Puget Sound Basin of Washington and the Willamette Valley of Oregon, and extends fully up to the five thousand foot level on the Cascades. This contains the Vancouveran fauna in its purest form and with its species but little modified throughout its extent. Characteristic Coleoptera of this area are *Omus dejeani* Reiche, *Cychrus tuberculatus* .Harr., *Carabus taedatus* Fab., in its typical form, *Nebria mannerheimii* Fisch., *Pterostichus herculaneus* Mann. and *Pterostichus validus* Dej., and *Miscodera insignis* Mann.

Next we have a subfauna that might be called the Pacific Maritime. This occupies that very wet region to the west of the Olympic and Coast Ranges of Washington and with secondary modifications taking place chiefly in northwestern Oregon, in southwestern Oregon and northwestern California, in Mendocino County, California, and south of the Russian River in California, extends down the coast as far as middle Monterey County, California. Within this maritime area, the fauna as far as the species are concerned, is quite similar to that found in the pure Vancouveran, but the form and appearance of many of the species has changed. Melanism is markedly evident here and is to be noted in such widely separated families as the *Carabidæ*, the *Elateridæ*, the *Cantharidæ* (*Lampyridæ*), the *Scarabaeidæ*, and the *Rhynchophora*. Increase in size is also to be noted with regard to many of the species. To illustrate this, I will cite but a few examples. In the *Carabidæ*, in the genus *Scaphinotus*, we have the species *S. angulatus* Harr. which is of a metallic purple color in those specimens dwelling in the Puget Sound Basin and the Willamette Valley, and absolutely black in those which are found in the wet coast belt, though otherwise unmodified. In southwestern Oregon and northwestern California, a related but distinctly different species, *S. behrensi* Roesck, is found replacing the above. *Scaphinotus angusticollis* Fisch. in the pure Vancouveran region from southeastern Alaska to the eastern side of the Willamette Valley, is typically of a ferruginous color. West of the Olympics and Coast Range of Washington and the Willamette river in Oregon, it is absolutely black. In Washington, it is structurally the same as the typical form; in western Oregon, larger and with

the alternate elytral intervals more reduced or irregular; in southwestern Oregon and northwestern California, it occurs with a more angulate prothorax, still more modified elytra, and with the male tarsi somewhat changed; while in the southern part of its range, in Mendocino and northern Sonoma County, California, it appears as a much larger insect and much modified in every regard. In *Pterostichus amethystinus* Dej. we have a species with bluish elytra which extends from Alaska to middle Mendocino County, California. South of this, it is replaced by *P. scutellaris* Lec., a species which has absolutely the same habitat and only differs from the preceding by being all black. It extends into Monterey County, California. Among the *Elateridæ*, we have numbers of species which like *Athous ferruginosus* Esch., have a black phase within the southern maritime area. In the genus Silis, the species and varieties found along the coast and in the high mountains of the Pacific Coast are mostly black, whereas in the interior lowlands they are yellow. Among the *Rhynchophora*, we have one, *Rhynchites bicolor* Fab., one of the most widely distributed weevils in North America which has its only known black phase in the middle coastal belt of Oregon.

A second and more greatly modified portion of the Vancouveran fauna is that which inhabits a strip of country that starts in the west central part of Oregon, runs south and southeast, including all of the moderately elevated mountains in Southern Oregon and Northern California, and extends along the western flanks of the southern Cascades and Sierras into Southern California and with breaks, also into the San Pedro Matir of Lower California. This subfauna I would call the Sierran. It occupies much of the same country as that covered by the western yellow pine, and though it receives many species from those faunas found immediately above and below it, is in no sense a transitional one as often called. It is a distinct subfauna and a direct offshoot of the Vancouveran. Its species are almost always either like those to be found in the pure Vancouveran or are derivatives of the same. In the northern area of the Sierran subfauna, certain species show a strong tendency to break up into many weak races which are more or less limited to various small areas. This unstableness is no doubt partly due to climatic and partly to topographical conditions, for the country is much broken up, there being many

small ranges with variously exposed slopes. In the region extending from Mt. Shasta south to the American river, some of the offshoots of the primitive species have segregated themselves into rather distinct species and subspecies, serving thereby to define this as a rather distinct subregion and one with a fairly well defined secondary fauna. In the territory running from the American river south to the Merced river, we find marked off in a similar way another secondary faunal area; in the southern Sierras, quite another; while in the San Bernardino Mts. there is still another. These secondary faunas, though not well defined by the majority of the Sierran species, are yet very distinctly outlined by others, as for instance, by certain species of *Omus*, *Scaphinotus*, *Pterostichus* and *Pleocoma*.

Two of the North American faunas most closely related to the Vancouveran and two, which like it, are most likely remnants of the same northern Tertiary fauna, are one small fauna confined to parts of the mountains of western Idaho, the Coeur d'Alene and Moscow; and the fauna of the upper levels of the southern Appalachian mountains, the so-called Alleghanian. These two are relict and endemic faunas and possess as would be expected, many species or related species in common. In the Idaho fauna, we have certain species like *Pterostichus sphodrinus* Lec. which are closely related to those found in the Vancouveran like *Pterostichus ovicollis* Schaef.; and others as *Scaphinotus relictus* Horn and *H. merkeli* Horn that have their nearest relatives in *Scaphinotus imperfectus* Horn, *S. debilis* Lec. and *S. incompletus* Schz. of the southern Alleghanies. In *Pterostichus* we have a peculiar and small group of species that have more or less prognathous mandibles and are quite subterranean in habit. On the Pacific Coast we have three, *P. caligans* Horn, being the best known, one in Idaho, and *P. grandiceps* Ch. and *P. rostratus* Neum. in the Appalachian Mountains. All of the above mentioned species are so highly specialized that they cannot be anything but relicts. They could not possibly have migrated to their present abode subsequent to the Glacial Period, though like the last mentioned, they might have extended their territory.

In the Cascades and Sierras, at elevations immediately above those occupied by the Vancouveran and its offshoot, the Sierran, we have a fauna that is more alpine in its nature.

The lower belt of that fauna, that found within the fir zone, is generally spoken of as the Canadian, that immediately above it and in the more barren treeless areas as the Hudsonian, and that on the tops of the high peaks as the Arctic. These faunas are in reality marginal or fringing faunas. They fringe the snow fields of the mountains and the barren wastes of the north, advancing and retreating with them, and have done so not only during the present period, but undoubtedly during the entire portion of the Great Ice Age, and I believe even before that were only to be found in the cooler areas of the north. During the period of greatest ice development, the Pleistocene, they were driven down to the lower levels and forced much farther south than they were before. With the decline of this period, they retreated both upwards and northward. At the more southern limits of their distribution their retreat was often prevented by breaks in the ranges or by the lowness of the mountains so that their continuity was interrupted leaving as we find today little islands of fauna here and there restricted to the more elevated parts of the high mountains.

The first of these, the Canadian, is in the west almost entirely a forest loving fauna. Where it comes in contact with the Vancouveran and Sierran, it blends to some extent with them and as a result is often hard to separate. It has also borrowed many species from these as they have from it. It commences in the north as a continuation on to the mountains of that extensive lowland fauna which populates the vast areas of western Canada. Then it continues south along the mountains, at first as a rather broad belt, later as a much narrower one, and wedged in between the Vancouveran and Sierran, and the Hudsonian on the west slopes; and the Great Basin fauna, a portion of the so-called Upper Sonoran, and the Hudsonian when the mountains are sufficiently high for that, on the east side. Its forest types of Coleoptera are fairly characteristic, such as many of its *Elateridæ* and *Cerambycidæ*, but its *Carabidæ* are less so. *Pterostichus protractus* Lec. and *Platynus bogemanni* Gyll. are, however, quite distinctive of it in the more southern Cascades and the Sierras.

The Hudsonian is in most places a very narrow zone, but it is very distinct. In Alaska, it is found on the uplands of the Aleutian Islands, on the mountains and the north side of the Alaska Peninsula, to quite an extent about the Kenai Peninsula,

and thence south along the flanks of the ranges which fringe the Coast. In British Columbia it is more inland and on the higher mountains and it continues as such along the Cascades of Washington and Oregon and the Sierras of California, but gradually ascends as it extends southwards. In the Cascades, as on Mt. Rainier, it is found at about seven thousand feet, on Mt. Shasta at eight thousand, in the Lake Tahoe region near nine thousand, while in the southern Sierras it is well above ten thousand feet. A few of its more widely distributed and characteristic beetles are *Nebria sahlbergi* Fisch., *Bembidium incertum* Mots., *Amara erratica* Sturm, and *Cryptohypnus bicolor* Esch. Besides these, there are certain others which are only to be found in the mountains of the West but which, because of certain peculiarities of distribution throw so much light upon the problem that they are worthy of being especially mentioned. Such is *Nebria trifaria* Lec. a large and very attractive black species. This is undoubtedly a glacial relict, for it is now only to be found high up near the snow fields on the Olympic Range, Mt. Rainier and Mt. Jefferson of the Cascades, and the Rockies of Colorado. The rare *N. ingens* Horn of the high southern Sierras, which differs from the preceding chiefly in having very much rounded humeri and atrophied wings, is, I am convinced, but a degenerate offshoot of the preceding which was forced south and later entirely separated from the parent stock. *Nebria ovipennis* Lec. and its three associated species are also of importance from the same viewpoint. They are all of moderate size, entirely apterous, and with elliptical elytra, hence extremely specialized and dependent upon their particular environment. The most northern, *N. kincaidi* Schw., an entirely metallic species of a purplish copper color, has been found close to the coast at Farragut Bay, Alaska, and near the snow fields on Glacier Peak and Mt. Rainier, Washington. A second, *N. columbiana* Casey, which resembles the preceding, but has only the elytra metallic, was described from British Columbia, but has also been found on Glacier Peak and Mt. Rainier, Washington, and Mt. Jefferson, Oregon. The third, *N. ovipennis* Lec., which is but an offshoot of the preceding and differs only in color, being entirely brownish or piceous, in other words more heavily pigmented, is to be found on the higher peaks of the Lake Tahoe region in California and above 10,500 feet in the southern

Sierras. The fourth species, *N. diversa* Lec. is of a yellowish color and is confined to the sea coasts of Washington and Oregon. The only close relatives that these four have are certain species found in the more eastern part of the Himalayas and in northeastern Asia. The last beetle to be mentioned in this connection shows another peculiarity of distribution due to the retreating ice. This is *Pterostichus brunneus* Dej., a species first described from Sitka on Baranoff Island, later found on Orcus Island near the mouth of Puget Sound and no doubt occurring on other islands in the same general region, and on the mainland only high up near the timber line as in the Selkirks of British Columbia, on Glacier Peak and Mt. Rainier in Washington, and on Mt. Jefferson in Oregon. On the islands, it was left stranded, but by adaptation was able to persist, while on the mainland it could preserve its natural environment by merely retreating with the ice to the higher levels.

The faunas of southern origin are to be found in their purest state only in the more southern part of our territory though derivatives of the same do in certain regions extend quite far to the northward. The best known of these is the Sonoran which, when considered in its strictest sense, may be said to occupy all those hot and more or less barren uplands in northern Mexico and the semi deserts and drier regions of our own Southwest, with extensions into western Texas, southern New Mexico and Arizona, and the more desert parts of southeastern California. The fauna of the Colorado Desert as well as that of its more upland extension, the Mojave Desert, is typically Sonoran. Certain elements of this also extend more westward along our southern border to the coast at San Diego and from the Mojave through the hot Walker Basin into the southern San Joaquin Valley. Here it is to be found mainly on the west side of the valley as in western Kern County and in an attenuated form in southern Monterey County. Some of its most characteristic beetles are among the wingless *Tenebrionidæ*, such as in the genera *Edrotes*, *Triorophus*, *Zopherus* and *Asida*, and in the wingless *Otiorychinæ* like *Ophrastes* and *Eupagoderes*, and the genus *Monilema* of the *Cerambycidæ*.

A derivative of the Sonoran fauna which is generally spoken of as the upper Sonoran, though it is more accurately defined as the Great Basin fauna, extends throughout the entire area

between the Rocky Mountains and the Sierra Nevadas, and thus includes northern Arizona, California east of the Sierras, Nevada, eastern Oregon and eastern Washington, Utah, parts of Wyoming, the lowlands of Idano, and reaches its northern limit in the Okanagan Valley in eastern British Columbia. Certain portions of this fauna also break through the mountain barriers on the west and thus extend themselves. South of Mt. Whitney a portion passes through the Walker Basin in company with the more typical Sonoran and extends into the San Joaquin Valley. Another portion runs westward from Modoc and Lassen Counties and passing north of Mt. Shasta, invades the northwestern part of Siskiyou County. The insects of this fauna are generally derivatives of the true Sonoran so not sharply differentiated. The *jejunas* group of the genus *Platynus*, *Agrilus walsinghami* Cr., and the hairy group of *Eleodes* are perhaps as characteristic as are any Coleoptera that we have in the subfauna.

That other southern fauna, the one which comprises the greater portion of the insect population of the southern part of California, is not a derivative of the present Sonoran. It is a fauna which has come to us directly from the south through Lower California and presumably in earlier times from lands farther to the south. It is very old and very distinct, having many genera and the bulk of its species totally different from those of the Sonoran. It came into California long before the Sonoran did and consequently is more thoroughly established in southern and middle California. The species are now some of the most characteristic within the state and the fauna as a whole is so dominantly Californian that it might be called the Californian fauna. It is now to be found not only throughout all of Southern California west of the San Bernardino and Sierra Madre Ranges, but along the coast to San Francisco, throughout the more southern portion of the Coast Range, and the greater part of the San Joaquin and Sacramento Valleys, extending as far north as Shasta County. In the drier parts of the state, it is therefore even more dominant than the Sonoran and it sends many of its characteristic forms well within that claimed by the Vancouveran and Sierran as in the foothill regions of the more northern Coast Range and the Sierra Nevada itself, thus sharing equally with the faunas of northern origin, the possession of the land. At one time, the

northern species extended much farther south than at present and in general were more in evidence in the south than now, but within recent times they have undoubtedly both retreated and decreased in numbers in the southern areas. The southern forms have, on the contrary, been doing the opposite so that they have gradually supplanted the preceding. This, therefore, accounts for the fact that there are islands of northern forms within the territory occupied by southern forms. Wherever southern forms have run north, they are always to be found connected with their basic stock in the south, no matter how far north they have gone and no matter at what time they advanced. Some of the characteristic species of the Californian fauna are the members of the *dilatatus* group of *Anisodactylus* in the *Carabidæ; Dystaxia, Schizopus* and *Glyptoscelimorpha*, in the *Buprestidæ; Ipochus fasciatus* Lec. in the *Cerambycidæ; Phloeodes, Coelus, Eulabis, Nycotporis, Cibdelis* and *Coniotis*, in *Tenebrionidæ;* and *Trigonscuta* and *Rhigopsis* in the *Otiorychinæ.*

Our west coast fauna we thus find has the bulk of its species of insects included within the very old Vancouveran fauna and the equally old Californian fauna, two faunas that are restricted to the Pacific Coast and that have passed through the Pleistocene without much injury to themselves. Supplementing these, are the several marginal faunas of the mountains and the desert faunas of the southeast. The Vancouveran, like those found in the mountains of western Idaho, and in the southern Alleghanies, is a relict fauna, a remnant of a more or less upland fauna which was widely distributed throughout the more northern parts of North America during Tertiary times. It is the largest remnant of the three and is only surpassed among similar fauna by that of the Japano-Manchurian region. The Californian is quite isolated though it shows a strong relationship to that found in the more barren parts of northern Chili and Peru. The marginal faunas on our mountains link up our territory with that to the north and northeast of us and the Sonoran does the same with regard to the country to the southeast. Certain of our peculiarities can also be indicated by considering the subject from a negative standpoint. For instance, we find that very little of the Neotropical or tropical fauna of South America, has reached us, whereas quite a noticeable amount has found its way into eastern North America. *Diabrotica soror* Lec. is one of our few derivatives

from that. We also lack the most characteristic elements of those faunas, the Austro-Riparian and Carolinian, which are such a feature of the eastern part of North America. Thus we have but a few *Scarabaeidæ* and few *Chrysomelidæ* as compared with the East; no representative of *Lucanus*, *Copris*, *Onthophagus*, *Anomala* and but few of *Phyllophaga* (*Lachnosterna*) from among the *Lamellicorns;* but a weak representation of *Melanotus*, an Elaterid genus rich in species in the eastern states; and not a single species of *Evarthrus*, *Pasimachus* and *Dicaelus* from among the Carabidæ. Hence we may say that the fauna of western North America as a whole when judged from the standpoint of its insects, is a most distinct one, yet one which can be linked with the faunas of the rest of the world.

A NEW CHALCID-FLY PARASITIC ON THE AUSTRALIAN BULL-DOG ANT.*

By CHARLES T. BRUES.

Several decades ago, Professor August Forel† found in cocoons of the large Australian bull-dog ant, *Myrmecia forficata* Fabr., two specimens of a fine Eucharid. He recognized them as parasites of the ant larvæ and sent them to the English hymenopterist, Peter Cameron, who described them as *Eucharis myrmiciæ*.‡ This was the first record of a Eucharid parasite of an ant, although several other genera have been reared subsequently from other ants and it seems likely that all of the Eucharidæ are ant-parasites.

Very recently Dr. R. J. Tillyard, of Hornsby, New South Wales, bred from a cocoon of *Myrmecia gulosa* another Eucharid which he sent to Prof. W. M. Wheeler, who has published accounts of the habits of Orasema and several other genera.§

The species reared by Dr. Tillyard is quite distinct from *Eucharis myrmiciæ*, although I suspect that both may belong to the same genus. Cameron's species is undoubtedly not an Eucharis as that genus is at present restricted and it may perhaps be a Psilogaster to which I believe the new species is referable. Psilogaster was first proposed for an Egyptian species by Blanchard and recently another one from Abyssinia has been more carefully described and figured by Reichensperger+ as *P. fraudulentus*. In addition to these, Dr. Wm. M. Mann tells me that he has a new species which he hopes soon to describe, taken by him in the Solomon Islands. The Abyssinian form occurs with *Pheidole megacephala*. Both of the African species have 11-jointed antennæ as does a Tasmanian Eucharid described by Walker as *Psilogaster pallipes*. Recently Girault has added one from Australia with 10-jointed antennæ, and has proposed the genus *Parapsilogaster* for another with 12-jointed antennæ. Since it is a difficult matter to say

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* Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 152.

† Am. Soc. Ent. Belgique, Vol. 20, p. 8. (1890).

‡ Mem. & Proc. Manchester Lit. & Philos. Soc., Vol. 4, p. 187. (1891).

§ Bull. American Mus. Nat. Hist., Vol. 23, pp. 1–93 (1907).

+ Zool. Jahrb. Abth. f. Syst., Vol. 53, pp. 185–218. (1913).

whether the apical part of the antenna ("club") consists of one, two or three separate joints, descriptions without figures may be misleading on this point. The species bred by Dr. Tillyard from Myrmecia differs considerably from *P. fraudulentus* in both the adult and pupa and as they occur with such different ants they may quite likely prove to be generically distinct. In accordance with the large size of Myrmecia, it is more than twice the size of the Abyssinian parasite of Pheidole and by reason of its striking color pattern may be very readily recognized.

Psilogaster fasciiventris sp. nov.

Imago. (Plate I, Fig. 2). ♀ Length 7.5 mm. Head and thorax greenish bronze, less greenish and with purple reflections on the propodeum; abdomen piceous, with transverse yellowish bands, orange yellow on the second segment and lighter yellow on the following segments; band of second segment narrowly interrupted on the median line and curving forward on the sides to near the apex of the petiole, separated by its own width from the apical margin of the segment; those of the following segments of similar form, but not interrupted medially, that of the fifth widened medially and angularly extended forward; petiole black with a purple cast; antennæ ferruginous, scape lighter; mandibles light brown; coxæ black, the front ones bronzed; femora fulvous; tibiæ and tarsi pale yellow, last tarsal joint black at apex; wings hyaline at base, brown elsewhere, more deeply so anteriorly near the middle. Head much narrower than the thorax, fully three times as broad as thick; posterior margin slightly concave; face below the antennæ transversely striate, the striæ continuing over the cheeks and upward behind the eyes and across the occiput; occipital margin raised; ocelli in a nearly straight line, the posterior ones nearly as far from one another as from the eye-margin; antennal basin transversely striated; eyes bare; malar space nearly as long as the eye; antennæ 11-jointed, scape twice as long as thick; pedicel very short; first flagellar joint as long as the scape and pedicel together, over three times as long as broad; following joints growing shorter, the seventh and eighth less than twice as long as thick; apical one longer. Thorax above coarsely rugose-reticulate; parapsidal grooves impressed only on posterior half; scutellum without distinct

median furrow or depression; separated from the post scutellum by a shallow groove, the two together acutely convex at apex, but without teeth or projections. Propodeum flattened and elevated medially, the sides of the central part convexly elevated at the sides, lateral to this with a deep groove extending to the hind coxa separating the lateral part which is acutely convex above near the root of the hind wing. Pleuræ sculptured like the mesonotum. Petiole of abdomen as long as the slope of the propodeum; second segment twice as long as the third and fourth together; following very short, not visible from above; apical margins of the second and third segments deeply excised medially. Tarsal claws simple. Submarginal vein thickened on its apical third; marginal half as long as the submarginal and fully four times as long as the short, stout, nearly perpendicular stigmal vein; postmarginal extending about half-way to tip of wing, but gradually evanescent at tip.

Type from Hornsby, New South Wales, in the writer's collection, bred from cocoon of *Myrmecia gulosa* by Dr. R. J. Tillyard.

Male. A pupa (Plate II, Fig. 2) shows twelve distinctly separate antennal joints and is, I suspect a male, and the apical joints are longer, more slender and of approximately equal length. In the female, if the lengthened and constricted 11th joint were regarded as two joints, the apical one would be much shorter than the penultimate.

Planidium, or First Larval Stage.

There are no specimens of this instar, but the cast skin of one was found still attached to the mature larva described below. This exuvium was firmly attached to the under surface of the thorax just behind the head and I have been able to remove it almost intact. When mounted in balsam it gives some idea of the structure of the planidium which proves to be very similar to that of *Perilampus* as described by Smith.*

Compared with Smith's figure (1912, p. 46, fig. 26 d), of the engorged planidium it appears to have eleven sclerites behind the head, while Perilampus has twelve. The apical plates are very small, however, and quite likely the number is the same in both genera. The head is separated from the

* Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser. No. 19, pt. IV, pp. 33-69 (1912) and Psyche, Vol. 24, pp. 63-68. (1917).

rest of the dorsal integument in the cast skin, showing that ecdysis must be accomplished by the formation of a dorsal rent behind the head. The thoracic and abdominal plates, except the last three are widely separated by the enormously distended membrane, so that they appear as widely separated bars like those of a much swollen termite queen. The first or prothoracic plate is broader than the others and crescentic, being deeply emarginate in front. The three following are narrower and but slightly curved; the following become gradually smaller to the minute apical one. At each side of each plate is a more or less triangular, paler extension, separated by a fine clear line; these probably represent pleural plates; they are similar to those of Perilampus in having the tip prolonged into a long bristle-shaped point, but the posterior edge bears several short teeth instead of bristles. Between the plates and on the ventral surface, the membrane bears some bristly hairs as in Perilampus, but the arrangement of these cannot be made out clearly in the specimen. I find no trace of the caudal bristles present in Perilampus, but these may easily have been lost in ecdysis.

Larva. Full-grown, length 12 mm. There is a single larva, evidently full-grown and ready to molt into the pupal condition as the appendages of the pupa are to be seen through the skin. The body is rather stout (Plate I, Fig. 1) nearly straight and broadest near the posterior end. At the anterior end there is a large vesicular swelling which extends ventrally, behind it on the ventral side lies another smaller swelling which evidently represents the head and mouthparts, although no definite structures can be made out. Dorsally, and to a less degree on the sides and below, the surface of the body is undulating, indicating eleven segments, including the anterior vesicle previously referred to. Of these segments the three anterior ones (thoracic) are larger than the basal abdominal ones, although the last several abdominal segments increase in size till the sixth is the largest body segment; beyond the segments become rapidly smaller and bent down ventrally; finally at the apex on the ventral side of the body is a minute tubercle which evidently is a twelfth segment. The surface of the whole body is clothed with minute, colorless, sparsely placed hairs which undoubtedly function as exudate organs.

Pupa. (Plate II, Figs 1, 2, 3). Length 15 mm. Elongate and slender, with the abdomen not noticeably swollen and not curved downward, the whole body with vesicular swellings. The head is bent under the thorax so as to be scarcely visible from above, but its projections extend forward as a central bifurcate, transversely wrinkled papilla and another one at each side projecting forward and outward. The mesonotum bears a small rounded tubercle at each side of the anterior edge, an acute one near each tegula and a widely separated pair of sub-acute ones on the disc before the scutellum; otherwise the integument is simple except for a raised, longitudinally wrinkled area between the anterior pair of tubercles. There are no tubercles above the propodeum and petiole like those figured by Reichensperger (*loc. cit.*) for *P. fraudulentus.*

Abdomen narrowly oval, broadest near the anterior end, composed of five apparent large segments and a short apical one, followed by a portion which appears to be retractile and composed of several fleshy segments, terminated by a polliciform projection. Dorsally the five large segments are separated by sharply elevated transverse ridges, each interrupted narrowly along the median line. At the median end each is elevated as a tooth, again as a more conspicuous and longer tooth at the lateral end, which is well down on the side of the body; midway between there is another tooth. Between the large teeth, especially near the dorsal line, there are more or less distinct minute denticulations. The ridges between all segments are very nearly of the same size, except that the lateral tooth-like projections of the first are much larger. The ventral surface is clearly separated by a slight ridge and groove just inside the intersegmental teeth and is less convex than the dorsal surface; only the second to fifth transverse ridges are clearly indicated; they are continuous and much less conspicuous than the dorsal ones; the first is faintly visible and bears an anteriorly directed tooth at its middle. Seen from below, the dorsal surface of the short sixth segment extends further down than the others leaving only a narrow ventral part which is conically elevated; in addition the apex of the fifth ventral segment bears a pair of closely approximated tubercles at apex; following retractile segments without distinctly separated dorsal and ventral surfaces.

Described from one perfect and several damaged specimens.

The very great similarity of the planidium stage of Psilogaster to that of Perilampus is extremely interesting and suggests a close affinity between the Eucharidæ and Perilampidæ as has already been pointed out by Smith from a comparison of the planidia of Perilampus and Orasema. In fact, this stage of *Psilogaster fasciiventris* is almost as close to that of *Perilampus hyalinus* as the latter is to "Perilampus, species a" figured by Smith. In this case it may of course be possible that "species a" is not a true Perilampus as Smith did not succeed in rearing the adult. The host relations are very different in the case of the two families so far as is known; all bred Eucharids have been found to be parasites of ants while Perilampus has been bred from a diverse series of hosts, including Lepidoptera, Coleoptera, Neuroptera and some parasitic Hymenoptera and Diptera.

The later larval and especially the pupal stages are much more highly modified in the Eucharids than in Perilampus, although in the larvæ there seems to be much diversity in this respect. In the case of the larva, that of Psilogaster is comparatively simple, without conspicuous exudate organs, although it is well supplied with minute surface hairs which no doubt function as secretory organs of this type. Orasema possesses numerous, highly developed exudate tubercles arranged segmentally on both the thorax and abdomen. On the other hand, Perilampus shows similar conspicuous tubercles and projections, although it seems improbable in view of the host relations in this case that these can function as true exudate organs. In the pupa, that of Perilampus is simpler, although with small intersegmented ridges on the abdomen. In Orasema the pupa exhibits well developed transverse welts between the abdominal segments as well as some on the head. The climax appears in Psilogaster where the exudate organs are extremely large and elaborate as described in the present account.

There would seem to be two possible reasons for the presence of the highly developed exudate-like organs on the Perilampus larva. It might be that Perilampus is derived from Eucharid-like ancestors in which these organs actually functioned for the elaboration of an exudate, but this seems highly improbable in view of the much more specialized habits and structure of the Eucharidæ. On the other hand, it may be that the integumental modifications of Perilampus really do function as exudate

organs. But if such were the case it seems impossible to point out any way in which they might bear any relation to the host. It is of course possible that neither of the foregoing suppositions is true, and that the apparent exudatoria or blood spaces between the body and integument are simply adaptations to assist in ecdysis. Such can hardly be the case however, as they do not exist in other parasitic Hymenoptera with habits similar to those of Perilampus and in which ecdysis must be undergone under the same conditions.

None of these suppositions seems adequately to explain the structure of the Perilampus larva and pupa, and unless the exudatoria are functionless their presence must be due to some other cause. It is barely possible that they may bear a relation to the host other than those enumerated above.

It is known that the larvæ or many if not all externally feeding parasitic Hymenoptera secrete a salivary liquid which is injected into the host. This contains digestive enzymes which act upon the tissues to induce extra-intestinal digestion and a consequent liquefaction of the food material which is then more readily ingested. In ants at least, as has been pointed out by Wheeler (1918) there are undoubtedly cases where such secretions have both a digestive and exudatorial function. With this in mind it is possible that the secretion which is actually produced on the surface of the body of the Perilampus larva (*vide* Smith 1912, p. 50) may have a digestive function. With this hypothesis there is one difficulty; only a small part of this secretion could possibly enter the wound caused by the feeding larva in the host.

Of all these conflicting suppositions none appears satisfactorily to explain the conditions as they occur in Perilampus, and it is perhaps more likely that the exudatoria may have been present in the common ancestors of both Perilampidæ and Eucharidæ. If such be true, they have persisted in both families and have in the Eucharidæ assumed a secondary function as their exudates have proved to be attractive to the ants upon which they are parasitic. We may then believe that they were originally either secretory or excretory organs, or those assisting in some way in the process of ecdysis

Tubercular excrescences of somewhat similar appearances are to be seen in many larval insects of very diverse groups, *e. g.*, in many caterpillars, in certain parasitic beetles, in one

genus of bees (Allodape) and in some ants. In connection with some of these, Professor Wheeler has suggested to me that they may be of assistance in eliminating the large amounts of water ingested by rapidly growing insect larvæ. Quite recently Roubaud* has figured (p. 15) larvæ of the remarkable Rhipiphorid beetle *Macrosiagon ferruginea* which are external parasites of the wasp, Synagris. In these larvæ the body is covered with tubercles much like those of Psilogaster and Perilampus. Roubaud also found in the larva of a Braconid parasite occurring in the nests of Rhynchium, transverse welts of apparently similar nature (*l. c.*, p. 35, Fig. 14). In this case the Braconid larvæ (*Allodorus major*) feed not upon the wasp larvæ, but upon one of the caterpillars used for provisioning the nest. They develop at an unusually rapid rate, and on this account may easily require additional facilities for excreting water, particularly as they possess a closed alimentary tract and must excrete all excess water through the skin. The habits of a somewhat closely related genus of Braconidæ, Chelonus, have been described by Pierce and Holloway in America.† This species is an internal parasite and undergoes a much slower development, the larva requiring about three weeks to mature. These writers do not describe the larva, but it seems probable that they are not tuberculate, as such a peculiarity would undoubtedly have been mentioned. It seems probable, therefore, that at least one form related to Allodorus, but developing more slowly, lacks the welts present in Allodorus. This would appear to lend color to the suggestion made above, that the welted or tuberculated integument may function in excreting excess water.

* Ann. Sci. Nat. Zool. 1916 Recherches biologiques sur les guêpes solitaires et sociales d' Afrique.

† Notes on the Biology of *Chelonus texanus* Cress., Journ. Econ. Entom., Vol. 5, pp. 425–428. (1912).

EXPLANATION OF PLATES.

PLATE I. *Psilogaster fasciiventris* sp. nov.

Fig. 1. Mature larva, lateral view.
Fig. 2. Female imago.

PLATE II. *Psilogaster fasciiventris* sp. nov.

Fig. 1. Pupa, lateral view.
Fig. 2. Pupa, ventral view.
Fig. 3. Pupa, dorsal view.

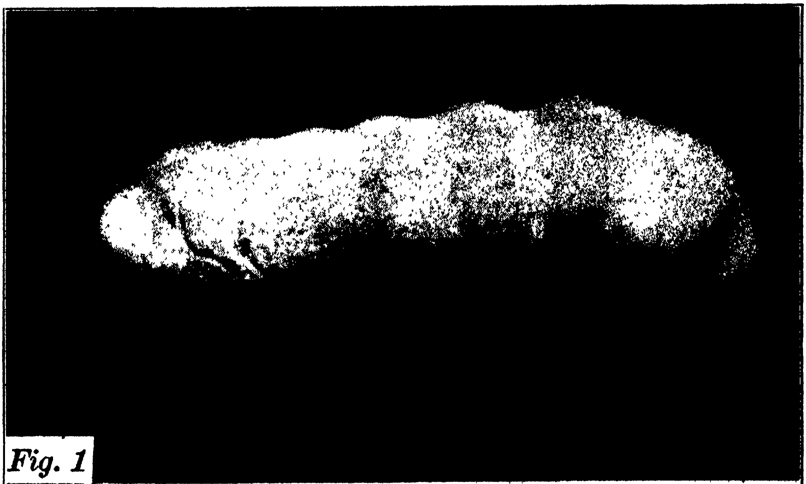


Fig. 1

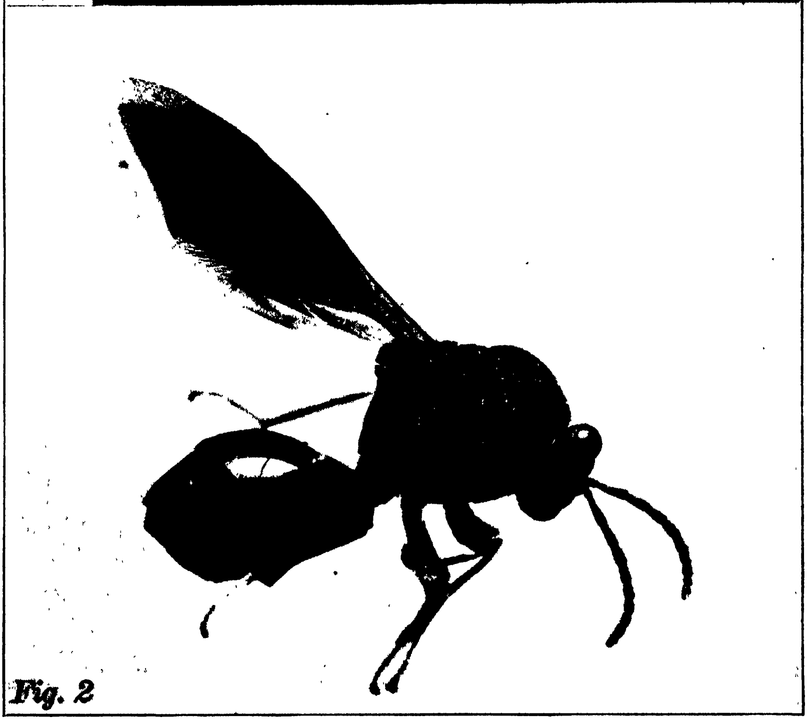


Fig. 2

C. T. Brues

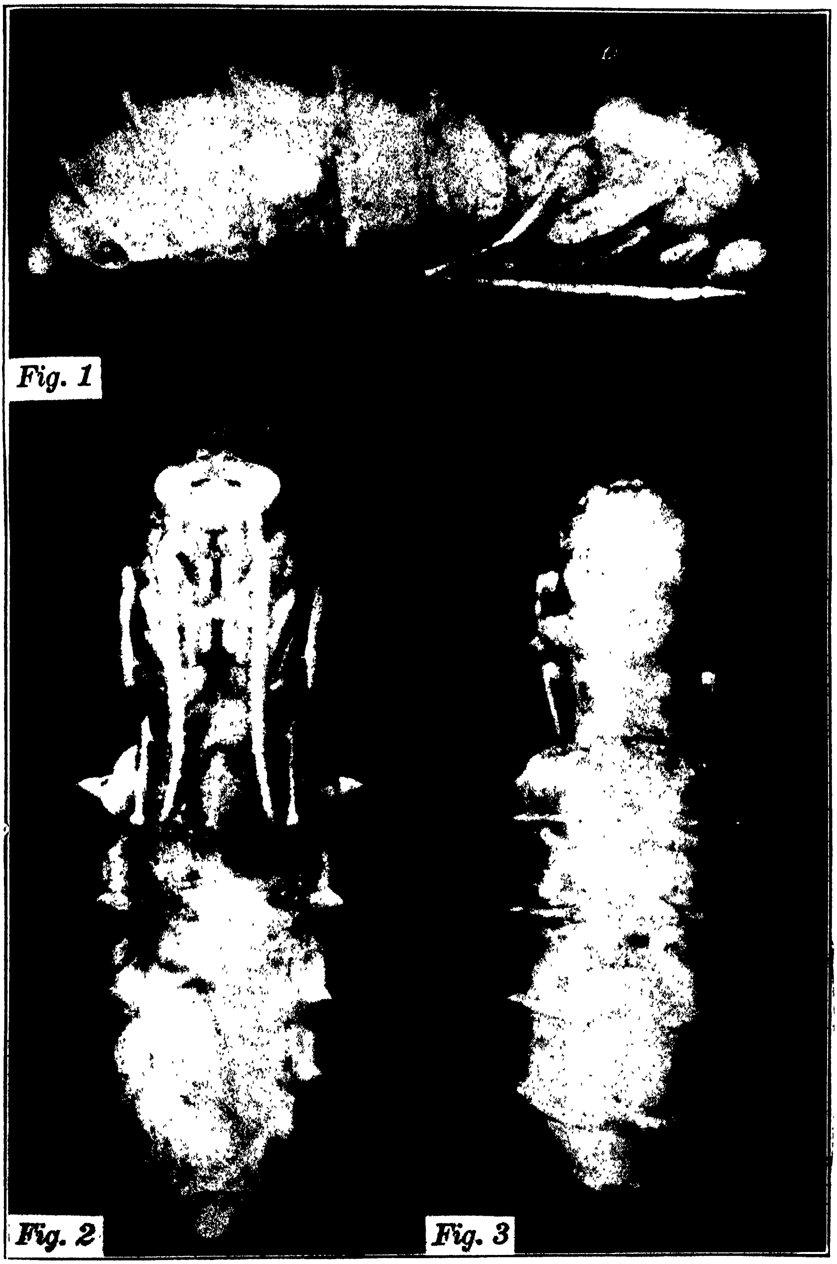


Fig. 1

Fig. 2

Fig. 3

C. T. Brues

NOTES ON THE CRANE-FLIES OF THE HAWAIIAN ISLANDS (Tipulidæ, Diptera).

By Charles P. Alexander, Urbana, Illinois.

During the past few years some extensive collections of Hawaiian crane-flies have been received from Dr. James F. Illingworth and Mr. O. H. Swezey, to both of whom I am indebted for many favors. The records of these collections, together with a few additional specimens from other sources, are herein recorded to supplement our scanty knowledge of the Hawaiian Tipulidæ. A few general statements of the faunal constituents may be given.

As might be expected, the crane-fly fauna of the Islands is strongly endemic. The dominant genus is *Dicranomyia* with about a dozen species, all of which are apparently confined to the Islands. The remaining genera, *Libnotes*, *Styringomyia*, *Gonomyia* and *Trimicra*, are represented each by a single species, all, with the exception of *Styringomyia didyma*, apparently being endemic. This last mentioned species breeds in decaying organic matter, such as manure, and has probably been spread over the Australasian islands through the agency of man. The entire lack of the larger, vigorous Tipuline forms is striking, but entirely in agreement with the fauna of many other oceanic islands, where the Tipulinæ are entirely lacking and the dominant genera are *Dicranomyia* and related groups, (Seychelles, Guam, Fiji, etc.)

The following transcription of a letter received from Dr. Illingworth will give a clear idea of the conditions under which Hawaiian crane-flies are found. Under date of March 6, 1917, he writes as follows:

"Last week end I spent in the Waianae Mountains, which are at the far end of the Island. The range is much older than the mountains near Honolulu (Koolau) and the native insect fauna appears to be more abundant.

"I have never seen crane-flies more abundant, but I fear they belong to a few species. I followed along the stream which had many falls—every wet cavern was filled with them. I tried sweeping the grass along the banks but with no success. One only gets crane-flies in the mountains here and it is a rather difficult matter to get to the places where they are abundant. One or two common species come to the lamps in the low lands—these I have sent before."

Since the appearance of the Fauna Hawaiiensis (1901) in which Grimshaw describes practically all of the Hawaiian crane-flies, a new species, *Dicranomyia foliocuniculator*, has been described by Swezey. This latter species is of extreme interest because of the leaf-mining habits of its larvæ—a habitat that is unique in the family so far as at present known.

The types of the new species, with the exception of *Dicranomyia swezeyi*, are in the writer's collection; this latter type and paratypes of the other species were returned to Mr. Swezey.

FAMILY TIPULIDÆ.

SUB-FAMILY LIMNOBIINÆ.

Genus **Libnotes** Westwood.

Libnotes perkinsi (Grimsh.)

This handsome crane-fly is common and apparently well distributed throughout the Islands. It was described as a *Limnobia* but the reference to *Libnotes* seems more nearly correct. The following additional records from Oahu are at hand:

Honolulu, April 10, 1914 (O. H. Swezey).

Nunanu Valley, May 4, 1915 (A. H. Case).

The exotic genera that center around *Limnobia* and *Dicranomyia* include members which run very close to the above groups. In their typical condition these genera (such as *Libnotes*, *Dapanoptera*, *Peripheroptera*, etc.) are well defined, but the presence of less clearly differentiated species tends to break down all distinctions. Speiser (1909) described three African species of *Limnobia* (*Limonia*) that are, in my opinion, referrable to two other genera, *Libnotes*, (*rhizosema* and *oresitropha*) and *Rhipidia* (*miosema*). Other authorities, as Bergroth, Edwards, etc., include the species of *Dicranomyia* that possess a long subcosta in the genus *Limnobia*, disregarding all other features of organization, and despite the fact that Osten Sacken in his classic monograph of a half century ago clearly differentiated these two groups of *Dicranomyia*. In determining the generic limits of this division of flies, other features of structure must be considered, and the entire burden not placed on a single character. When this is done, the habitus of the insect and the smaller details of structure that are perceivable but difficult of definition, will aid in separating various groups. It is admittedly true that in many such cases the reference of species to genera becomes largely a matter of personal opinion. The

suggestion has been made that it would perhaps be better to consider these diverse Limnobiine genera as lesser groups, such as sub-genera, but in my opinion no benefit would be derived from such an action, since it would be exactly as difficult to separate and define these sub-genera. These various exotic genera are probably valid, but *Goniodineura* van der Wulp is doubtfully distinct from *Libnotes*.

Genus **Dicranomyia** Stephens.

Dicranomyia stygipennis, sp. n.

Coloration dark brown throughout, including the wings.

Male: Length, 6–7.5 mm.; wing, 7.5–8 mm.

Female: Length, 6.4–8.5 mm.; wing, 7.8–9 mm.

Rostrum and palpi dark brown. Antennæ dark brown throughout, the flagellar segments elongate-oval. Head dark brown.

Thorax dark brown, the pronotum a little yellowish. Legs dark brown, the extreme base of the femora a little paler. Halteres dark brownish black throughout. Wings with a strong brown suffusion; stigma rather distinct, of a somewhat darker brown. Venation: *Sc* ending about opposite the origin of the sector, Sc_2 close to the tip of Sc_1; *Rs* about twice the length of the basal deflection of R_{4+5}; cell *1st* M_2 closed; basal deflection of Cu_1 at the fork of *M*.

Abdomen dark brown. Hypopygium of male with the ninth pleurite small, only about four-tenths the length of the ventral pleural lobe; ventral lobes large, fleshy, the basal inner angle suffused inwardly, near its base with two powerful spines; dorsal lobes short, stout, slightly curved, the tip of each produced into a slender, blackened spine.

Holotype, ♂, Waianae Mountains, Oahu, altitude 2000 feet, March 5, 1917 (J. F. Illingworth).

Allotype, ♀, with the type.

Paratypes. Very numerous specimens of both sexes, from the type locality; Kaupo, Maui, altitude 2000 to 4000 feet, January 1, 1915 (H. T. Osborn); Haleakala, Maui, altitude 9000 feet, September 27, 1914 (H. T. Osborn).

This common fly is notable by its dark coloration. I would have identified it as being *D. brunnea* Grimsh. (1901) except for the discrepancy in the coloration of the wings. In any case, Grimshaw's name is preoccupied by *D. brunnea* Doane (Journ. Ent. N. Y. Soc., Vol. 8, p. 184; 1900), a fact that was pointed out by the author several years ago (Psyche, Vol. 18, p. 194; 1911).

Dicranomyia grimshawi, nom. n.

New name for *D. apicalis* Grimsh. (1901), not *D. apicalis* (Wied.) (1828).

Two males from Olaa, Hawaii, altitude 2500 feet (W. H. Ashmead), in the collection of the U. S. Nat. Museum.

Dicranomyia hawaiiensis Grimsh.

This beautiful *Dicranomyia* is widely distributed in the Islands. The following additional records of distribution are available. Island of Oahu: Honolulu, February 7, 1913 (O. H. Swezey); Palolo, February 8, 1914 (O. H. Swezey); Olympus, September 8, 1912 (O. H. Swezey); Waianae Mountains, altitude 2000 feet, March 5, 1917 (J. F. Illingworth).

Dicranomyia foliocuniculator Swez.

This recently described species is apparently common and widely distributed in the Islands. As stated before, it is unique in the leaf-mining habits of the larva, a habitat that will probably be found to be shared by other species of the Islands; especially *D. jacobus*, *D. swezeyi*, etc., forms that are undoubtedly related to *D. foliocuniculator*.

Numerous specimens are available from the Waianae Mountains, Oahu, altitude 2000 feet, March 5, 1917 (J. F. Illingworth) associated with *D. hawaiiensis*, *D. stygipennis*, etc. This locality has been mentioned in the introductory paragraph of this article. Waimano, Oahu, January 5, 1913, (O. H. Swezey). Iao Valley, Maui, altitude 700 feet, January 3, 1914 (J. F. Illingworth).

Dicranomyia jacobus, sp. n.

Size larger than in *foliocuniculator* (length of the male over 4 mm.); coloration of the body darker brown; wings with a decided brownish tinge.

Male: Length, 4.3–4.4 mm.; wing, 5.2–5.5 mm.

Female: Length, 5.1–6.5 mm.; wing, 5.8–6.2 mm.

Rostrum and palpi dark brownish black. Antennæ rather short, dark brownish black, the flagellar segments short, suboval to rounded, the apical segments more elongated. Head dark brown.

Neck rather elongated. Thorax very high and gibbous, dark brown, without stripes (in alcohol). Halteres rather short, the knobs large, the stem pale, the knobs darker, brown. Legs with the coxæ and trochanters brown; remainder of the legs rather dark brown. Wings light brown, the stigma indistinct, only a little darker than the remainder of the wings; veins dark brown. Venation: *Sc* short, Sc_1 ending about opposite or slightly beyond the origin of *Rs*; Sc_2 removed from the tip of Sc_1 for a distance about equal to cross-vein *r*; *Rs* long, somewhat arcuated, from two to three times as long as the basal deflection of R_{4+5}; cell *1st* M_2 large, as long as the veins issuing from it; basal deflection of Cu_1 just before, at, or even slightly beyond, the fork of *M*.

Abdomen dark brownish black, the sternites a little paler. Hypopygium with the ninth tergite almost straight across the caudal margin; pleurites rather short, shorter than the apical lobes; ventral inner side of the pleurite produced entad into a complex lobe which is expanded at its apex and bears at the inner margin a lateral cylindrical lobe with long hairs. Dorsal apical appendage a chitinized rod almost straight basally, toward the tip slightly bent inward and acutely pointed; ventral apical appendage a large fleshy lobe whose inner margin subapically is produced into a long, slender, cylindrical, chitinized point, rather blunt at the apex and here with a few hairs; at its base on the outer side with two sharp chitinized spines which are directed backward. Anal tube short, very broad, projecting slightly beyond the caudal margin of the ninth tergite, its apex feebly concave. Penis guard elongate, narrowed toward the apex which is bent strongly ventrad.

Holotype, ♂, Iao Valley, Island of Maui; altitude 700 feet; January 3, 1914 (J. F. Illingworth).

Allotype, ♀, topotypic.

Paratopotypes, 2 ♂'s, 2 ♀'s.

This insect is respectfully dedicated to Dr. James F. Illingworth, to whom I am indebted for many favors.

Dicranomyia swezeyi, sp. n.

Coloration pale yellow throughout; wings yellow; cell *1st* M_2 open by the atrophy of *m*.

Female: Length, 2.8–3 mm.; wing, 3.7–3.8 mm.

Rostrum and palpi pale yellowish brown. Antennæ short, pale brown. Eyes black. Head light yellow.

Thorax pale yellow, the præscutum a little brownish. Pleura sparsely dusted with gray. Legs with the coxæ pale; femora pale brownish yellow, the tips brown; tibiæ and tarsi yellowish brown. Halteres pale. Wings pale yellow, the stigma pale brown; veins yellow. Venation: *Sc* short, ending before the origin of *Rs; Rs* moderately elongated, about one and one-half the length of the deflection of R_{4+5}; deflection of R_{4+5} strongly arcuated at origin; cell *1st* M_2 large, subquadrate, indistinctly open by the atrophy of *m;* basal deflection of Cu_1 just before the fork of *M*.

Abdomen brownish yellow, dorsal valves of the ovipositor moderately elongated and quite strongly arcuated.

Holotype, ♂, Olympus, Oahu, September 8, 1912 (O. H. Swezey).

Allotype, ♀, with the type.

This interesting little species is dedicated to its collector, Mr. O. H. Swezey, to whom I am indebted for many favors. It is apparently related to *D. foliocuniculator* Swez., but is readily distinguished by its very small size, uniform pallid coloration, and the open cell 1st M_2.

Genus **Styringomyia** Loew.

Styringomyia didyma Grimsh.

Specimens are in the collection from Honolulu taken in May, 1914. It is apparently well distributed throughout parts of Australasia.

Genus **Trimicra** Osten Sacken.

Trimicra lateralis Grimsh.

Specimens from Honolulu, April 10, 1914 (O. H. Swezey).

Genus **Gonomyia** Meigen.

Gonomyia (Leiponeura) **hawaiiensis,** sp. n.

Coloration dark brown; antennæ dark brown, the first flagellar segment light yellow; thoracic pleura striped with brown and white; wings with a pale brown tinge, longitudinal veins long and slender.

Female: Length, 3.2–3.4 mm.; wing 3.2–3.5 mm.

Rostrum and palpi dark brown. Antennæ dark brown, the first segment of the flagellum yellow. Head gray.

Mesonotal præscutum dark brown, the extreme lateral margin pale; remainder of the thoracic notum dark brown. Pleura white, with a dorsal dark brown longitudinal stripe; a ventral brown stripe occupying the sternum. Legs with the coxæ yellowish; trochanters and femora brown, the apices of the latter and the tibiæ a little darker; tarsi brownish yellow. Halteres dark brown, the knobs conspicuously light yellow. Wings pale brown, iridescent, the stigma indistinctly darker brown; veins brown. Venation: Sc short, ending before the origin of the sector; Rs long, gently arcuated; basal deflection of R_{4+5} very short; longitudinal veins beyond the cord elongated; basal deflection of Cu_1 at or before the fork of M.

Abdomen dark brown, the ovipositor with the dorsal valves very long and slender, slightly up-curved, dark brown at the base, horn yellow beyond.

Holotype, ♀, Koolau Mountains, Oahu, altitude 1500 feet, February, 1917 (J. F. Illingworth). Found on a wet bank.

Paratypes, ♀'s, Wailuke, Oahu, January, 1915 (O. H. Swezey); Tantalus, Oahu, October 15, 1911 (O. H. Swezey); Palolo, Oahu, February 8, 1914 (O. H. Swezey).

The type of the subgenus *Leiponeuri* Skuse (Proc. Linn. Soc. New South Wales, ser. 2, vol. 4, p. 795; 1889) is *Gonomyia gracilis* (Skuse); the name is homonymous with *Gonomyia gracilis* (Zett.) (1838) and is here renamed *Gonomyia* (*Leiponeura*) *skusei,* nom. n.

THE CALIFORNIAN SPECIES OF MALTHODES.

By H. C. Fall.

The presence of several species of Malthodes among the things which Dr. Blaisdell has asked me to study in connection with his forthcoming paper on the Coleoptera of Humboldt County, California, offers the opportunity of reviewing the Californian species of this genus in the Doctor's and my own collections, a very large proportion of which are as yet undescribed.

These delicate little things have been generally neglected by collectors, and such cabinet specimens as one runs across are too often ruined in mounting. When carefully collected and mounted, they are wonderfully interesting little creatures and offer an almost unparalleled wealth of sexual variation in the formation of the terminal abdominal segments of the male. The females are on the other hand rather monotonous in their uniformity, and are rarely distinguishable specifically except as accompanied by males. In the males themselves there are few taxonomic characters outside of the ventral sexual modifications, and this together with the fact that there is little use in attempting to give comparative measurements in insects having such fragile structure and soft integuments, is a sufficient reason for the brevity of the following descriptions, which indeed might about as well have been made still shorter.

Very little has been said in the descriptions about the females. These almost invariably differ from the males by the smaller, less prominent eyes and consequently narrower head, which is usually scarcely as wide as the thorax; by the shorter antennæ, with joints two to four more nearly equal in length, or at least with the third joint not longer than the second; by the rather more transverse thorax, and sometimes somewhat shorter elytra. The last ventral segment in this sex is rather deeply incised in the same general manner in all the species here treated.

The remarkable modifications of the abdominal apex in the male are often difficult to see in their entirety, but the form of the sixth and seventh ventrals is usually visible, and these

have therefore been selected for representation in the accompanying plate. These sketches are not drawn to any given scale, and are not to be regarded as absolutely accurate as regards relative dimensions of parts, but they are sufficiently so for the purpose they are designed to serve. A certain degree of variation has indeed been observed in these dimensions in one or two species, quite independent of any extension or contraction of the parts, which though sometimes noticeable, is less common than one would expect.

In Le Conte's latest treatment of the Lampyridæ* there is given a table of our species of Malthodes, of which three—*laticollis*, *fragilis* and *fusculus*—are accredited to California. The type of *fragilis* is from the Atlantic Coast region, and an examination of the Le Conte specimens some years ago convinced me that the Californian form so referred was not the same. This latter did not appear to be identical with any of the new species herein described. This leaves only two LeContean species described from the state, one of which, *fusculus*, I do not recognize in the material at hand. To these two species must be added the *M. ligulifer* described by Bergroth† from Monterey, California, and said to be related by its male sexual characters to *spado* Lec. The prothorax of *ligulifer* is said to be "nigro-piceus, anguste luteo-circumlimbatus," which does not apply normally to any Californian species known to me, and is only approached by some forms of *basalis*, near which it may be listed for the present; the terminal ventral segments of the male are, however, not defined with sufficient exactness to enable me to include it in the following table.

* Trans. Am. Ent. Soc. 1881, p. 60.
† Ann. Soc. Ent. France (Bull. Ent. CCIII) 1889.

TABLE OF SPECIES.

1. Seventh ventral segment of male not produced, sixth broadly, not deeply emarginate, fifth broadly angulate emarginate.
   Female apterous .... *reflexus*
   Female winged .... *laticollis*
   Seventh ventral segment of male more or less strongly produced, sixth very broadly and deeply emarginate, fifth not emarginate.
   Seventh ventral of male rounded at tip, size large .... *magister*
   Seventh ventral of male emarginate, notched or forked at tip 2
2. Seventh ventral of male not or scarcely more than twice as long as wide, never projecting beyond the sixth a distance as great as the length of the latter 3
   Seventh ventral segment of male much more than twice (usually three to five times) as long as wide, and projecting beyond the sixth a distance equal to or greater than the length of the latter 4
3. Seventh ventral of male deeply incised at tip, eyes very large, separated anteriorly by not more than their own horizontal width as viewed from the front .... *vigilans*
   Seventh ventral of male broadly notched or emarginate at tip.
   Antennæ with two basal joints yellow .... *basalis*
   Antennæ entirely fuscous or piceous.
   Eyes large and prominent, the head conspicuously wider than the thorax, thorax yellow .... *mitificus*
   Eyes relatively small, head not very much wider than the thorax, the latter piceous .... *piceolus*
4. Seventh ventral of male with apical notch not deeper than the width of the segment at its narrowest part 5
   Seventh ventral of male more deeply forked than the minimum width of the segment 6
5. Apex of seventh ventral of male concavely beveled inferiorly, as seen in profile.
   Seventh ventral of male nearly straight in profile .... *mollis*
   Seventh ventral of male distinctly ascending in profile, the tips more diverging as viewed vertically .... *appendiculatus*
   Apex of seventh ventral of male simple.
   Fifth (?) dorsal segment (♂) with a strongly produced overhanging process which is horizontally dilated and rounded at tip, broadly arched as viewed in profile; seventh ventral not bisinuate ... *obductus*
   Dorsal segments not produced apically, seventh ventral of male strongly bisinuate in profile .... *bicurvatus*
6. Ascending portion of seventh ventral straight (in profile) and lying between long, slender, rectangularly bent dorsal processes .... *complicatus*
   Ascending portion of seventh ventral straight, tip beveled, no slender dorsal processes, ventral segments 3 to 5 silvery sericeous at middle .... *sericeiventris*
   Ascending portion of seventh ventral sinuous or bent.
   Emargination of sixth ventral (♂) not truncate at bottom, seventh of nearly uniform width, forks parallel.
   Head (♂) much wider than the thorax, eyes large, separated in front by about their own diameter .... *vapidus*
   Head (♂) narrower eyes smaller and separated on the front by more than 1½ times their own diameter .... *fusculus*
   Emargination of sixth ventral truncate at bottom.
   Seventh ventral sinuate apically in profile, less widely and deeply forked .... *tularensis*
   Seventh ventral apically bent, more widely and deeply forked.. *visceratus*

Malthodes reflexus sp. nov.

Piceous, prothorax not paler. Antennæ piceous, basal joint not appreciably paler, about reaching the elytral tips in the male, a little shorter in the female, joints 2–4 subequal, the third scarcely or barely as long as the second, the fourth only slightly if at all longer than the second, intermediate joints two and one-half times as long as wide in the male, twice as long as wide in the female. Head subequal in width to the thorax in the male, obviously narrower than the thorax in the female; eyes not very prominent, the width of the front between them fully three times that of the eye. Prothorax quite strongly transverse, sides slightly convergent from the anterior angles to the base, the margins more strongly reflexed than usual; disk biimpressed at middle, surface distinctly, moderately closely punctate. Elytra normal in the male, in the female much shorter, less than twice as long as wide, the wings entirely wanting, and the abdomen projecting beyond the elytra a distance as great as the elytral length. Length about 2 mm.

Abdominal sexual characters. The seventh ventral of the male is not produced, the genital appendages are similar in type to those of *laticollis*, the lateral processes broader basally, rapidly narrowing to the acuminate tip, which is slightly curved or everted, central piece not keeled beneath, but angularly prominent at tip superiorly, the filamentous process inferior in position; last ventral of female acutely rather deeply incised.

California. Middle coast region. 4♂, 5♀, sent by Dr. Blaisdell.

Specific localities are: Marin Co. (type ♂); Fairfax, Marin Co., V-7-11; Vine Hill, Contra Costa Co., VI-7-08; Niles Canon, V-16 (W. M. Giffard).

Very easily recognizable by the entirely piceous color, broad distinctly punctate thorax with entire side margin reflexed, simple, non-produced seventh ventral of male, and apterous female.

Malthodes laticollis Lec.

Piceous or piceo-testaceous, head darker, thorax yellow with the front angles more or less infuscate. Antennæ fuscous, basal joint paler, as long as the body in the male, second and third joints equal, fourth just visibly longer, intermediate joints about three times as long as wide. Head slightly wider than the thorax in the male, eyes moderately large, their longest diameter not much less than the minimum width of the front between them; head in the female a little narrower than the thorax, the eyes notably smaller. Thorax strongly transverse, a little more so in the female as usual, widest at the front angles, which are reflexo-incrassate, sides nearly straight and parallel posteriorly, the margin distinctly reflexed throughout; surface evidently but finely

punctate, disk biimpressed at middle, sometimes only feebly so. Length about 2½ mm.

Abdominal sexual characters. Seventh ventral of male simple and not produced; genital appendages short, consisting of two piceous slender lateral processes, hooked (abruptly bent at right angles and acuminate) at tip; a central piece, pale in color, broad at base, with a very thin laminate keel beneath and a curved terminal filamentous process.

California. Described from Santa Cruz Island. Specimens in my collection are from Riverside, Pomona, Pasadena, Mt. Wilson and San Bernardino Mts., May, July.

The abdominal characters of the male as given by Le Conte in his synopsis of the Lampyridæ (Trans. Am. Ent. Soc., 1881, p. 60), do not seem to apply to the species here described, but the fact remains that there are no males in the Le Conte collection. Two females only represent the species, the first (on the label) being the original Santa Cruz Island type, while the second—a later acquisition—is evidently a different species. Specimens of the species I have described above were carefully compared with the Santa Cruz type and are to all appearances identical.

Malthodes magister sp. nov.

Piceo-testaceous, head darker, thorax fulvotestaceous with a blackish discal spot in the type which is nearly obsolete in a second example. Antennæ entirely fuscous, passing the elytral tips in the male; joints 2–4 distinctly increasing in length, the intermediate joints fully four times as long as wide. Head (♂) distinctly wider than the thorax, eyes only moderate in size, separated in front by more than twice their own width as seen from the front. Thorax but slightly wider than long, the front angles a little prominent and reflexed, sides behind the angles narrowly margined, surface finely sparsely punctulate. Length 4.5 to 5 mm.

Abdominal sexual characters. Male: Sixth ventral deeply, broadly emarginate; seventh moderately produced, tip gradually narrowed and rounded, entire. Within the seventh ventral is a broad tongue-like process which is emarginate at tip. The terminal dorsal segments project considerably beyond the ventral at apex. Female not known.

California. Humboldt Co. The type collected at Blair's Ranch, Redwood Cr., Sept. 6, by H. S. Barber; the second example at Green Point, June 4, by Dr. F. E. Blaisdell. This is the largest species yet discovered in our fauna and is quite distinct in the male sexual characters.

Malthodes vigilans sp. nov.

Piceo-testaceous, head darker, thorax yellow. Antennæ fuscous, slightly longer than the entire body in the male, joints 2–4 increasing in length, the third however, only slightly longer than the second; intermediate joints (♂) about five times as long as wide, (♀) twice as long as wide. Head much wider than the thorax in the male, scarcely at all so in the female; eyes (♂) very large and prominent, separated in front by but little more than their own width. Thorax moderately transverse, a little more so in the female as usual, sides parallel, feebly margined, the margin just perceptibly thicker at the front angles, surface scarcely visibly punctate. Length about 3 mm.

Abdominal sexual characters. Male with sixth ventral deeply, broadly emarginate, seventh rather short and broad, projecting beyond the sixth a distance less than the length of the latter, the tip deeply narrowly incised. Last dorsal not projecting beyond the last ventral. Female as usual.

California. San Bernardino Mts., July; 2♂, 1♀, collected by the writer. The type is a male.

Malthodes basalis sp. nov.

Fuscous, front anteriorly yellow, prothorax varying from yellow with faint diffuse fuscous discal cloud, to nearly evenly fuscous with the extreme basal and apical edge yellow. Antennæ fuscous with basal two joints yellow, as long as the body in the male, joints two to four increasing slightly in length, intermediate joints about three times as long as wide. Head (♂) slightly wider than the thorax, the eyes only moderately prominent, separated in front by twice their own width or slightly less. Thorax moderately transverse, sides parallel, narrowly margined, the front angles scarcely more prominent. Length 2 to 3 mm.

Abdominal sexual characters. Male: sixth ventral deeply emarginate; seventh broad, nearly straight in profile, extending beyond the sixth a distance subequal to the length of the latter, the tip broadly emarginate; last dorsal not produced.

California. Yosemite, June 16 (W. M. Giffard), sent by Dr. Blaisdell; Licking Fork, Mokelumne River, June, (Blaisdell); Lake Tahoe, July 17-21.

Nevada. Ormsby Co., July (Baker).

Fifteen examples are before me. The type is a Yosemite male.

The bright yellow basal two joints of the antennæ will probably serve to separate this from the other California species.

Malthodes mitificus sp. nov.

Fuscotestaceous, thorax yellow. Antennæ longer than the body in the male, entirely fuscous, joints two to four distinctly increasing in length, intermediate joints about four times as long as wide. Head (♂) conspicuously wider than the thorax; eyes large and prominent, separated anteriorly by a distance not much greater than their own diameter. Prothorax moderately transverse, sides parallel, narrowly margined, front angles slightly thickened but scarcely more prominent; surface shining, minutely sparsely punctulate. Length about 3 mm.

Abdominal sexual characters. Male: sixth ventral deeply emarginate, seventh broad, extending beyond the sixth by about the length of the latter, gradually narrowed apically, the tip broadly notched; last dorsal segment not produced.

California. Mokelumne Hill. 5♂, sent by Dr. Blaisdell.

This species should be easily recognizable by the tabular characters. The ventral sexual structure is nearly as in *basalis*.

Malthodes piceolus sp. nov.

Piceous, elytra, body beneath and legs more or less piceotestaceous as usual. Prothorax entirely piceous except for paler basal and apical edge; mouth yellowish in some examples, not so in others. Antennæ entirely dark, fully as long as the entire body in the male, in which sex joints two to four are evidently increasing in length, and the intermediate joints fully four times as long as wide. Head a little wider than the prothorax in the male, eyes not very large, separated anteriorly by rather more than twice their own width as viewed from the front. Prothorax only moderately transverse, sides parallel or slightly convergent behind, margin narrow, slightly thickened at the front angles, surface moderately shining and very finely punctate. Length (head deflexed) 2 mm. to tip of elytra.

Abdominal sexual characters. Male: sixth ventral deeply emarginate, seventh broad, nearly parallel, passing the apex of the sixth by a distance rather less than the length of the latter, tip broadly not deeply emarginate, a little deflexed at its extremity as seen in profile.

California. Green Point, Humboldt Co., June 4-7 (Blaisdell). The type is a male.

Malthodes mollis sp. nov.

Fuscotestaceous, head blackish, thorax rufotestaceous, frequently with a more or less evident diffuse darker discal shade. Antennæ about as long as the body in the male, entirely piceous, second and third joints subequal, the fourth slightly longer; intermediate joints three to three and one-half times as long as wide. Head a little wider than the thorax in the male, the eyes not very prominent. Thorax moderately transverse, sides parallel, margin fine, not appreciably thickened at the front angles. Length about 2½ mm. to the tips of the elytra.

Abdominal sexual characters. Male: sixth ventral deeply emarginate, seventh rather broad, strongly produced, passing the sixth by nearly twice the length of the latter, gradually somewhat narrowed apically, the tip notched or narrowly emarginate, medially grooved or impressed and appendiculate each side near the base of the emargination; last dorsal not produced, broadly rounded at tip.

California. Marin Co., numerous specimens from Muir Woods, IV-23; Lagunitas, IV-25, and "Marin Co," (type ♂), all sent by Dr. Blaisdell.

Var. **longipennis** var. nov.

Two examples (♂, ♀) from Eureka, Cal. (H. S. Barber), are provisionally separated as a variety of the preceding. In the male the elytra seem slightly longer than in the typical form, or any other form known to me; the antennæ are a little paler basally, the seventh ventral of the male narrower, not medially impressed beneath at tip, the appendix therefore not double, but continuous from side to side.

Malthodes appendiculatus sp. nov.

Fuscous, thorax yellow. Antennæ (♂) attaining the tips of the wings, fuscous, basal joints paler; third joint slightly or scarcely longer than the second, fourth evidently longer, intermediate joints four times as long as wide. Head distinctly wider than the thorax, eyes rather large, separated anteriorly by a distance less than twice their width as viewed from the front. Thorax moderately transverse, sides just perceptibly converging posteriorly, margin fine, scarcely thickened at front angles. Length 3½ mm. to tip of wings.

Abdominal sexual characters. Male: sixth ventral deeply broadly emarginate; seventh rather narrow, passing the sixth by nearly twice the length of the latter, gradually narrowed for three-fourths its length, then widening, ascending and forked at tip, each fork appendiculate beneath or emarginate at tip as viewed in profile; last dorsal not produced, broadly rounded at apex.

California. "Mts. near Claremont" (Baker); Pasadena.

A single male from each locality, the first named being the type.

This species is rather closely allied to *mollis*, but differs appreciably in the seventh abdominal segment of the male, which is here narrower, curved upward at its extremity, the forks more divergent. The eyes are a little more prominent, the thorax feebly narrowed posteriorly, and there are some other slight differences which may however be constant. The genital appendages also appear to be different, but these are not very clearly visible in *mollis*. In *appendiculatus* there is a long curved central ligula narrower than the seventh ventral,

above which it lies, horizontally flattened and notched at tip, and on either side of this a very slender straight needle like process.

Malthodes obductus sp. nov.

Brownish testaceous, thorax yellowish, disc clouded with fuscous. Antennæ as long as the body in the male, fuscous, the basal joints paler; joints two and three subequal, four a little longer, intermediate joints about three and one-half times as long as wide. Head obviously wider than the thorax in the male, the eyes only moderately prominent. Thorax moderately transverse, sides straight and parallel or very nearly so, side margins fine, not thickened at the front angles. Length 2 mm. to tip of elytra.

Abdominal sexual characters. Male: fifth dorsal segment strongly produced, arched, overhanging the terminal segments, broader at tip, which is truncate with rounded angles, strongly carinate beneath except at apex, which is concave; sixth ventral deeply, broadly emarginate; seventh strongly produced, deeply notched at apex, in profile bent upward a little at about apical third, the tip again horizontal.

California. Green Point, Humboldt Co., June 4-7 (Blaisdell); Washington, Seattle (Prof. O. B. Johnson).

The type is a male from the first named locality.

In the typical form the apical notch of the seventh ventral is as deep as the terminal width of the segment. In the Seattle males the segment is more deeply cleft, the forks more diverging and the tip of the produced fifth dorsal is a little different. These may represent a closely allied species, but as the sexual modifications are of the same type throughout, I prefer to consider it a varietal form.

Malthodes bicurvatus sp. nov.

Fuscotestaceous, thorax entirely yellow, head piceous. Antennæ as long as the body in the male, fuscous, scarcely paler basally in fully colored specimens; third joint slightly or scarcely longer than the second, fourth distinctly longer than the third, intermediate joints about four times as long as wide. Head evidently but not greatly wider than the prothorax, eyes only moderately prominent. Thorax moderately transverse, sides straight, finely margined, front angles not thickened. Length (head deflexed) about 2 mm. to tips of elytra.

Abdominal sexual characters. Male: last visible dorsal segment broadly truncate, the lateral angles produced downward and backward in a rather broad process which is dilated and rounded at tip. Sixth ventral broadly deeply emarginate, the curvature becoming more narrowly parabolic at the bottom of the emargination; seventh ventral narrow, elongate, notched at tip, bisinuate in profile, with a short tooth-like process at middle of upper side.

California. Mokelumne Hill, April (Blaisdell), type ♂; Adams Springs, Lake Co., June 18 (Blaisdell).

Malthodes complicatus sp. nov.

Fuscotestaceous, head piceous, thorax entirely yellow or with the extreme margin at apical angles infuscate. Antennæ longer than the body in the male, entirely fuscous, second and third joints subequal, fourth evidently longer, intermediate joints more than four times as long as wide. Head (♂) wider than the prothorax, eyes moderately prominent. Prothorax moderately transverse, sides parallel and narrowly margined, margin not appreciably thickened at the front angles. Length (head deflexed) 2¼ mm. to tips of elytra.

Abdominal sexual characters. Male: last (?) dorsal with a slender descending lateral process, which is abruptly bent at right angles, the terminal portion horizontal. Sixth ventral deeply, broadly emarginate, the bottom of the emargination truncate; seventh ventral received between the descending dorsal processes, elongate, narrow, forked rather deeply at tip, obliquely ascending in profile in its apical two-thirds.

California. Pomona, March 25 (type ♂); Pasadena; Claremont (Baker); Santa Barbara, Feb. 4; Ojai Valley, March 5.

Superficially closely resembling the preceding species, but very distinct by the sexual characters.

Malthodes sericeiventris sp. nov.

Fuscotestaceous, head piceous, thorax entirely clear yellow. Antennæ as long as the body in the male, entirely fuscous, joints two to four visibly increasing in length, intermediate joints nearly five times as long as wide. Head (male type) notably wider than the thorax, with prominent eyes; less wide in a second male. Thorax moderately transverse, sides straight and nearly parallel, side margins fine, not appreciably thickened at the front angles. Length (head deflexed) 2½ mm.

Abdominal sexual characters. Male: ventral segments 3 to 5 silvery sericeous at middle throughout their length; sixth deeply emarginate; seventh elongate, narrow, deeply divergently forked apically, in profile obliquely ascending in about its apical half, the tips of the forks thickened and concavely beveled.

California. Pomona, April 25-May 20; 2 ♂, 2 ♀; type ♂.

The sericeous ventral area of the male is quite unique and has the appearance of an excessively short and dense silvery pile, but it is not resolvable, as such by a ¼ inch triplet, and is probably due to surface sculpture.

Malthodes vapidus sp. nov.

Fuscotestaceous, head piceous, thorax yellow. Antennæ entirely fuscous, as long as the entire body in the male; joints two to four increasing in length, intermediate joints four times as long as wide. Head much wider than the thorax, the eyes large and prominent, separated anteriorly by not more than their own diameters. Thorax moderately transverse, sides straight and nearly parallel, side margins very fine, not thickened appreciably at the front angles. Length (head deflexed) about 2 mm. to tips of elytra.

Abdominal sexual characters. Male: last dorsals not produced; sixth ventral deeply broadly emarginate; seventh ventral rather wide, parallel sided, deeply widely divided at apex, sinuately ascending in profile.

California. Lake Tahoe, July 17-21, '97 (type ♂).

Malthodes fusculus Lec. Proc. Acad. Nat. Sci. Phila. V, p. 346.

Le Conte's description, Synopsis of Lampyridæ, Trans. Am. Ent. Soc., IX, 1881, is as follows:

"Last ventral (♂) bent in a sinuate manner obliquely upwards and more deeply nicked at tip than in *fragilis;* prothorax transverse, finely margined, tinged with testaceous; head black, eyes large, prominent, antennæ long, slender, fourth and following joints longer than the second or third, ♂ two-thirds, ♀ one-half as long as the body. Length 3 mm. Cal."

A variety is mentioned with the prothorax "yellow testaceous ♀."

While probably most closely related to *vapidus*, this species is at once separable by the much smaller eyes and consequently narrower head, which is not very much wider than the prothorax. The last ventral is forked in a similar manner, but the emargination is much less deep than in *vapidus*, the depth being subequal to the width of the segment at the bottom of the emargination, while in *vapidus* it is much deeper than the segmental width at this point. In *fusculus* the forks comprise not more than one-fourth the entire length of the segment, in *vapidus* about one-half the length of the segment.

The type was taken at or in the vicinity of San Francisco.

Malthodes tularensis sp. nov.

Fuscous, thorax yellowish, more or less tinged with fuscous, especially along the side margins. Antennæ entirely fuscous, as long as the body in the male; third joint scarcely longer than the second, fourth evidently longer, intermediate joints four times as long as wide.

Head evidently wider than the thorax, eyes moderately prominent. Thorax quite strongly transverse, sides straight and parallel, rather strongly margined. Length (head deflexed) 2¼ mm. to tips of elytra.

Abdominal sexual characters. Male: sixth ventral very deeply, broadly emarginate, the emargination truncate at bottom, seventh narrow, very elongate, polished, yellow, very sparsely pubescent, gradually narrowed for two-thirds its length, then widened and deeply forked; as viewed in profile, horizontal in rather more than basal half, then rather abruptly sinuately ascending; last dorsal not produced.

California. Tulare Co., June 25, 2♂, 1♀. Type ♂.

Malthodes visceratus sp. nov.

Fuscous or fuscotestaceous, thorax yellow with side margins more or less infuscate. Antennæ entirely fuscous, as long as the body in the male, third joint but slightly longer than the second, fourth a little longer, intermediate joints fully four times as long as wide. Head (♂) not much wider than the thorax, narrower than the thorax in the female. Thorax strongly transverse in both sexes, sides nearly straight and parallel, strongly margined, the margin thickened at front angles. Length 2 to 2½ mm.

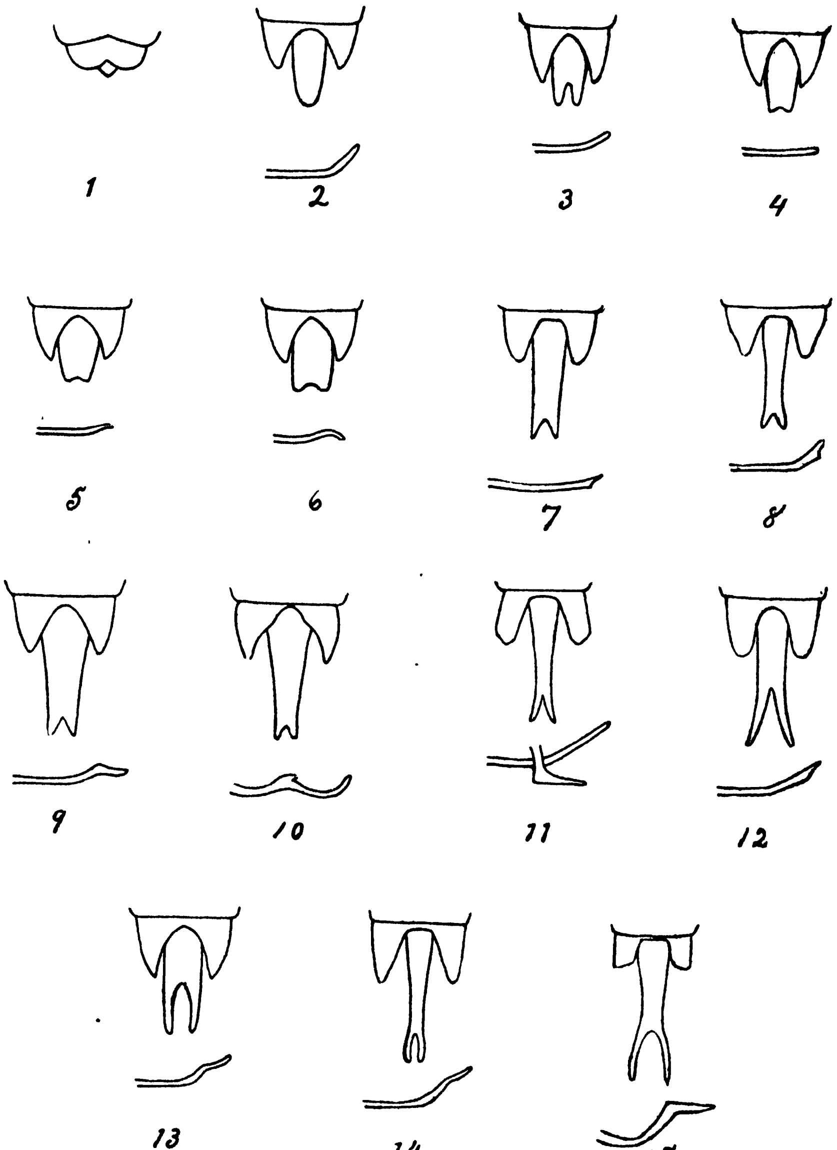
Abdominal sexual characters. Male: sixth ventral broadly, deeply emarginate, the emargination truncate at bottom; seventh elongate, deeply, broadly divided at apex, the forks slender, strongly up-curved basally in profile, then bent suddenly in horizontal direction; sixth (?) dorsal acutely projecting downward at sides to enclose the last ventral.

California. Mill Valley, III-3-'07 (type ♂); Mt. Tamalpais, V-1-'13; Green Point, Humboldt Co., VI-5-'16; Mariposa Co., VI-16 (W. M. Giffard), all from Dr. Blaisdell.

EXPLANATION OF PLATE III.

All figures show the outline of the sixth and seventh ventral segments of the male, and beneath them in each case, except Fig. 1, the seventh ventral as viewed in profile. In *complicatus*, Fig. 11, is shown also one of the downward projecting dorsal appendages, between which the seventh ventral lies.

Fig. 1. Terminal ventral segments of *Malthodes reflexus* and *laticollis*.
Fig. 2. Same of *magister*.
Fig. 3. " *vigilans*.
Fig. 4. " *basalis*.
Fig. 5. " *mitificus*.
Fig. 6. " *piceolus*.
Fig. 7. " *mollis*.
Fig. 8. " *appendiculatus*.
Fig. 9. " *obductus*.
Fig. 10. " *bicurvatus*.
Fig. 11. " *complicatus*.
Fig. 12. " *sericeiventris*.
Fig. 13. " *vapidus*.
Fig. 14. " *tularensis*.
Fig. 15. " *visceratus*.



H. C. Fall

NOTES ON THE REPUGNATORIAL GLANDS OF CERTAIN NOTODONTID CATERPILLARS.

Glenn W. Herrick and John D. Detwiler.

In the course of a study which the writers are making of the life histories and habits of the red-humped apple caterpillar (*Schizura concinna*) and the yellow-necked caterpillar (*Datana ministra*), the junior author noted that while handling the caterpillars of the former species, especially when they were pinched with forceps, a considerable amount of moisture would suddenly appear in an area about the body of the larva as it lay in the hand or rested upon the table. Curiosity as to the source of the moisture was aroused and the following experiments were made by the writers to determine its origin, nature, and method of dispersion.

The presence of repugnatorial eversible glands in Notodontid caterpillars has been known since the time of DeGeer, and Packard* gives a list of nine species in which the glands have been found. *S. concinna* appears in the list and Packard remarks as follows concerning it.

"While examining the very gaily colored and heavily spined caterpillars of *Schizura concinna*, I observed that when a fully grown one was roughly seized with the forceps or fingers it sent out a shower of spray from each side of the prothoracic segment, exactly like that of *Cerura* and *Macrurocampa*." Several years previously a note from C. S. Denham† appeared in Insect Life in which he said that in rearing a brood of these caterpillars he "discovered that they had the power to emit quite a quantity of strong hydrochloric acid strong enough to be decidedly corrosive to the skin and easily perceptible in the atmosphere."

In investigating the source and nature of the moisture which appeared whenever the Schizura larvæ were handled at all roughly it soon became evident that these caterpillars possessed considerable amounts of the liquid and that they were able to eject it to a surprisingly long distance and over a comparatively large area. In determining the habits and behavior of the different individuals of *Schizura concinna* in ejecting the liquid

* Jr. N. Y. Ent. Soc., Vol. III, pp. 110–127, 1895.
† Insect Life, Vol. I, p. 143, 1888.

the caterpillars were placed on large sheets of blue litmus paper and were then irritated at different points on the body by pinching them with forceps. It was difficult to see the spray on account of its fine misty quality. Occasionally, by getting the caterpillar in just the right position between the observer and the rays of light, one could see a tiny jet or cloud of mist. The effect on litmus paper, however, was instantaneous and conspicuous, for every drop that touched the paper changed it to a characteristic red color. Moreover, the area covered by the spray and the distance to which it could be ejected were easily and accurately determined. The following experiments and observations on *S. concinna* illustrate the action of the glands.

A full-grown larva was carefully placed near the center of a large sheet of litmus paper. While in this position it was pinched with tweezers on the fifth abdominal segment. At once a fine invisible spray was thrown out around the body in a posterior direction. An area surrounding the body about 3 inches wide and 5 inches long was colored solidly red, while about the lateral and posterior borders of this solidly colored area was a field covered with drops of various sizes. From right to left the farthest drops were 5½ inches apart.

The larva was pinched again near the thorax, the main pressure being exerted on the right side of the body. There was an immediate spray toward the right and in a posterior direction. The farthest drop posteriorly was 7½ inches from the caudal end of the abdomen, while the farthest drop laterally was 5¼ inches from the body. Figure 1 shows the pattern of the spray on the litmus paper.

An attempt was made to determine the direction of the spray in relation to the point of irritation. When irritated on the right side and the head left free, the head is thrown to the right and the spray is directed largely to the right side of the body. When irritated on the left side the movement of the head is in that direction and the spray is directed mostly to the left. When irritated near the posterior end of the abdomen there is a decided tendency for the spray to be thrown in a posterior direction. When pinched just behind the hump on the second thoracic segment all of the secretion was projected backward and to the left. In case of this particularly vigorous larva the drops were thrown approximately 7 inches distant in a lateral direction from the head and in a posterior direction

to the distance of 7½ inches. Again the larva was touched lightly on the right side of the body. The head was immediately turned to the right whereupon a sudden pinch with forceps caused the liquid to be projected in a fine spray almost entirely on the right side of the body. In all, this larva was irritated seven distinct and successive times. It responded to each of the first six irritations by an ejection of liquid although in a lesser quantity toward the end, while no response was obtained from the seventh irritation. Evidently the supply became exhausted or the larva became fatigued and indifferent to the irritation.

Fig. 1. Spray pattern (½ size), reproduced from litmus paper, of one ejection of liquid by a vigorous larva. C, position of caterpillar.

Since the direction of the spray appeared to correspond to the direction in which the head was free to move we obtained a fresh larva and held the head so that there was practically no movement to the right or left. In response to stimulus under these conditions the larva was still able to throw a spray of the liquid to the distance of from 6 to 7 inches, but wholly in a posterior direction over the entire body. This experiment was repeated with another larva with similar results. It appears evident that the caterpillar can direct the liquid backward to a distance of several inches even though the head be prevented from free movement to the right or left. Moreover, experiments show that the larva can project the spray in an anterior direction.

The caterpillars under observation were too far advanced to determine whether the larvæ possess functional glands in all of the earlier instars. A late brood, however, was found in which the larvæ were in the next to the last instar. One of these larvæ, after what seemed to be a greater degree of irritation than usual, did eject a considerable quantity of the fluid, the farthest drop falling at a distance from the body of about 3¼ inches. We hope to be able, next season, to make further investigations of this phase of the subject.

The opening of the gland is a narrow transverse slit on the ventral side of the prothorax close to the cephalic border of this segment. The gland is sack-shaped and situated within the thoracic cavity. It appears to be quite similar to the corresponding gland in *Cerura vinula* described by Klemensiewicz.* Further detailed description of this gland and its morphology will be presented by the Junior author in a later paper.

Regarding the chemical nature of the secretion it is sufficient to say here that it gives a marked acid reaction with blue litmus paper and that it has a pungent and characteristic odor that immediately suggests acetic acid. The subject is under careful investigation in conjunction with Professor E. M. Chamot of the chemical department, the results of which will be given in a later paper. Suffice it to say, the investigations indicate that the secretion is formic acid. Poulton† has already shown that the secretions from the similar gland in *Cerura vinula* is formic

* Verhandlungen d. Zool. Bot. Gesellsch in Wien. Vol. 32, pp. 468–474, 1882.
† Trans. Lon. Ent., Soc. for 1886, p. 157.

acid. The effect of the fluid on the skin is such as to cause burning and itching similar to the effect of the common plant known as "nettles." However, this effect is not so noticeable unless the quantity falling on the hand is of considerable amount.

It is hoped that opportunity may be found next year for further observations and experiments on these glands in other members of the genus.

The authors desire to express their acknowledgment to Miss Ellen Edmonson for her careful reproduction of the spray pattern in Figure 1.

NOTES ON THE IMMATURE STAGES OF DELTOMETOPUS RUFIPES MELS. (Coleoptera, Eucnemidæ).*

EDNA MOSHER.

Larvæ of the family Eucnemidæ have been somewhat of a puzzle to entomologists since the first description of a larva of Fornax by Coquerel in 1856. The first American species were described by Osten Sacken, from larvæ collected by Dr. Horn and an unnamed species from his own collection. The larvæ are found in dead wood, some of them where it is still very firm, others, including the species under discussion, prefer wood which is more decayed. Although living in the wood, they differ very materially from the ordinary type of wood-boring insects for they have no powerful mandibles such as these insects are provided with. Instead the head strongly resembles that of the leaf-mining larvæ without having even as efficient mandibles as they. Schiodte quotes Coquerel as saying that they are "without perceptible organs of the mouth—nay without a buccal orifice." It has been doubted by some authors, including Schiodte, that they were able to make their own burrows and were suspected of living in burrows made by other insects. The same authors also differed as to the food of such larvæ, considering their lack of mouthparts, and Schiodte seemed certain that they must feed on xylophagous larvæ and pupæ, since it was quite evident they could not feed on wood. Some have thought they lived on the sap or "juices of the wood." Little has been added to our knowledge of the larvæ or pupæ since Osten Sacken's paper was written. Since these larvæ seemed to be such an entomological puzzle, I have been much interested in collecting them from time to time in the last five years. Altogether three species have been collected, but only one or two specimens each time, and all my attempts at rearing them have been unsuccessful. Mr. H. G. Crawford, however, found one of these species very abundant at Guelph, Ontario and succeeded in rearing a number of adults. I am greatly indebted to him for placing all of his material at my disposal, and also to Mr. Charles Dury, of Cincinnati, who identified the species for me as *Deltometopus rufipes* Mels.

* Contributions from the Department of Zoology and Entomology, Ohio State University, No. 56.

LARVA: The larva is depressed, somewhat moniliform, pale yellow in color, with dark brown on the head, prothorax and ninth abdominal segment. When full-grown it averages 14–16 mm. in length, or when fully expanded, as much as 18 mm. The head is subtriangular in outline, heavily chitinized and nearly all dark brown as shown by the stippled portions in Figs. 1 and 2. The pale lines seen on either side of the head capsule (Figs. 1, 2, 3, 4) may indicate sutures, as the head capsule will break along these lines when softened. If they are sutures, their homology is doubtful; but as they are furrows on the ectal surface and ridges on the ental they are perhaps for the attachment of muscles. The head is much thinner cephalad and laterad of these lines. Along the cephalic margin of the head capsule are two small triangular projections and four similar, but larger ones, along the lateral margin, making it serrate. The lateral margin also has a prominent blunt projection caudad of the serrations. The head is inserted into the prothorax and may move laterad until this blunt projection strikes the dark brown protuberance on the prothorax. The head may also be moved dorsad and ventrad, and a prominent projection like a condyle on the meson of each caudal margin seems to facilitate these various movements and also prevents the head from being shoved farther back into the prothorax. The very dark line extending caudad from each cephalic projection (Figs. 3 and 4, t) marks the attachment of a strongly chitinized bar to each surface, which is probably the tentorium. Between these two bars at the cephalic end of the head is an opening, the entrance into the buccal cavity. There are no ocelli present. The head capsule is sparsely covered with very minute setæ. The appendages of the head are all retractile. Their location is indicated in Fig. 3, where they are shown extruded. Normally only the extreme tips of the mandibles are visible and then only under high power, as all of these structures are exceedingly minute. What I have considered the antenna (Fig. 5) looks very like a maxilla but does not seem to be in any way connected with the buccal cavity. Its median projection at the distal end seems to be covered with sensory structures and the lateral projection ends in at least three finger-like projections. The structures articulated to the tentorial bar are certainly the mandibles (Figs. 6 and 7, md). Each moves in a horizontal plane and has one very long tendon.

Mesad of these are a group of structures which seem to be maxillæ and labium but these can only be seen distinctly under the oil immersion lens. The median portion, which is pointed at the end (Figs. 3 and 8, lb) has a longer, sharp projection on either side which appears to be two-segmented. The dorsal surface of this structure (Fig. 8) shows a long tube connected with the median projection which I have traced back into the prothorax and may be the alimentary canal, although it is very small and the salivary duct should open here. The tube seems to have a chitinous lining, however. Laterad of these structures and slightly dorsad of them are what appear to be maxillæ. The distal end bears a cluster of projections which appear to be arranged in a circle. These structures are only a little less strongly chitinized than the mandibles. There has been so little morphological work done on this type of head that one is rather at a loss to account for their peculiar structure and extremely doubtful as to the homology of parts.

The entire surface of the thorax and abdomen is very finely striate, except when otherwise indicated, and all the body segments are very similar, except that the thoracic segments are shorter in proportion to their width than those of the abdomen. There are no traces of legs or prolegs. Each segment except the caudal one has some very distinct areas which appear velvety under a low power lens as if densely covered with fine setæ. On the dorsal surface of the prothorax this area is triangular and located near the caudal part of the segment but on the other thoracic segments it is cephalic and somewhat triradiate. The areas are ovate on the abdominal segments and located near the cephalic margin. The areas are the same shape on the ventral surface except that the median projection is lacking on the mesothorax and metathorax. These areas are really covered with scales as shown much enlarged in Fig. 11, and a few fine setæ are also present. Caudad of these velvety areas on the mesothorax and metathorax, on both surfaces, are much coarser striations than on the remainder of the segment. Near the caudal margin of each body segment except the prothorax and the last abdominal segment on both surfaces, and the eighth segment on the dorsal surface, is a clear, smooth area clearly outlined by a fine, slightly elevated, brown, chitinous ring. These are almost semicircular in outline on all segments except the ventral surface of the eighth abdominal, where it is much

smaller. The ninth abdominal segment is apparently the last one, although the portion surrounding the anal opening probably represents the tenth segment. It is outlined and almost covered with coarse, triangular spines. The remainder of the ninth segment is sparsely covered with very minute setæ. On both surfaces the heavily chitinized caudal portion is punctate. At the caudal end of this segment are two minute spines. The spiracles are easily visible on the lateral part of the mesothorax and first eight abdominal segments (Fig. 9). In the spiracular region are a number of structures which seem to be olfactory pores. The arrangement is shown on one segment in Fig. 9 and several very much enlarged in Fig. 10. These seem to be all of the simple type as shown in McIndoo's Fig. 19. A few sensory pores were also located on the head, and what appeared to be a compound one with several openings was found on each side of the ventral surface of the prothorax. These show as a round white spot on the large, brown area on each side of the meson. Nearly all of the body segments have a small, lateral projection which seems to aid in locomotion, as the larva moves on either side as well as on either dorsal or ventral surface.

PUPA: The pupa (Figs. 12 and 13) is very much like that of an elaterid and does not differ in essential details from any other coleopterous pupa. The entire body, including appendages, is densely covered with very fine pubescence. In dorsal view (Fig. 12) a small portion of the head is visible and the thoracic and nine abdominal segments clearly defined. A deep furrow between the thorax and abdomen allows for considerable movement. The caudo-lateral angles of the prothorax are produced for at least one-fourth the total length of the segment. The first eight abdominal segments bear spiracles but those of the first, and sometimes those of the eighth, are concealed. The lateral margin of each abdominal segment is more flattened than the remainder and separated from it by a slight furrow as indicated by dotted lines. There are many long, soft setæ on the various body segments as indicated in the figure, the row on the base of the mesothoracic wings being quite prominent. In ventral view (Fig. 13) it will be seen that none of the head sutures are visible, the antennæ are closely approximated and mandibles, maxillæ and labial palpi are easily distinguished. The prosternal spine and its groove on the mesothorax are easily seen and all of the appendages are quite normal in

arrangement. A portion of the seventh segment is elevated and extends as a flap over a portion of the eighth when the body is curved. The elevated portion containing the anal opening is probably the tenth segment. Figs. 12 and 13 show a female pupa. The arrangement of the caudal segments is somewhat different in the male as shown in Fig. 14. The length of the female averages 8 mm., the male 6 mm. The color is white until the color of the developing beetle begins to show when it appears to be a dull brown.

This species apparently takes three years to mature, as larvæ of three different sizes have been taken in the same log in autumn. The larvæ are certainly able to bore into wood. They seem to use the serrate margin of the head to assist progress and probably hold themselves firmly in a partially-formed burrow by the lateral protuberances on the segments, especially the strongly chitinized one on the prothorax. The burrows are very small and not easily detected, but some of the wood where they were found did not need much boring as the larvæ could almost push their way along. As to their food, I cannot state positively, but they have always refused any insect larvæ placed in the cages, and have lived for at least eight consecutive months on nothing but wood. In the case of larvæ feeding in very firm wood there never seems to be any "sawdust" or frass about, but very frequently a clear liquid is seen to be expelled from the anus. Even such facts as have been discovered about the mouth-parts will not entirely solve the problem.

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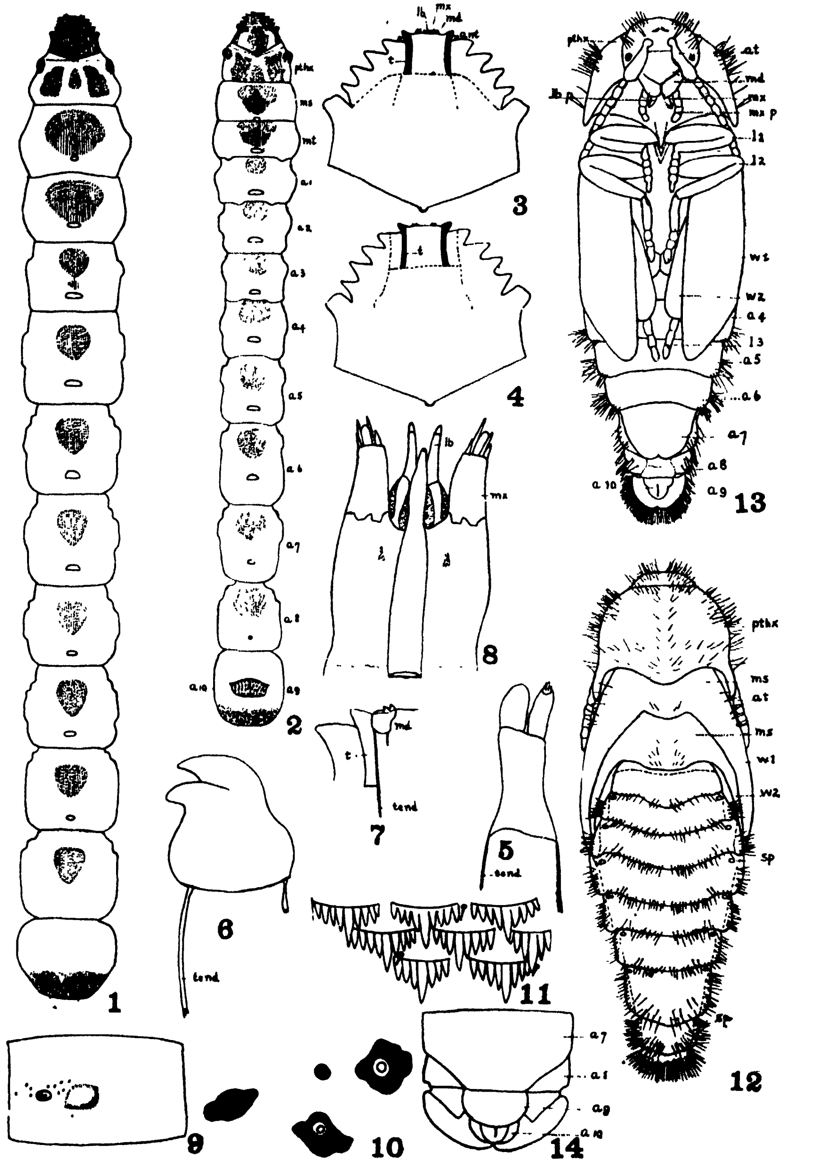
EXPLANATION OF PLATE IV.

Fig. 1. Dorsal view of larva with all the segments extended to their full length, as when the larva is in motion.
Fig. 2. Ventral view of larva, with some of the segments retracted as they appear when the larva is inactive and in most alcoholic specimens, (drawn to slightly smaller scale).
Fig. 3. Dorsal view of head showing mouth-parts extruded.
Fig. 4. Ventral view of head showing mouth-parts retracted.
Fig. 5. Dorsal view of antenna and tendons.
Fig. 6. Mandible and tendons.
Fig. 7. Showing articulation of mandible.
Fig. 8. Dorsal view of labium and maxillæ.
Fig. 9. Lateral view of fourth abdominal segment showing location of spiracle and sensory pores.
Fig. 10. Several sensory pores greatly enlarged.
Fig. 11. Arrangement of scales on "velvety" areas.
Fig. 12. Dorsal view of female pupa.
Fig. 13. Ventral view of female pupa.
Fig. 14. Ventral view of caudal segments of male pupa (without setae).



Edna Mosher

RESOLUTIONS ON THE DEATH OF DR. S. W. WILLISTON.

Dr. Samuel Wendell Williston, who was an early member and fellow of this society and was elected an Honorary Fellow in 1916, died in Chicago, Ill., August 30, 1918. He was born in Boston, Massachusetts, July 10, 1852, and had achieved an almost unique position in American Science for the present period in that he had attained distinction in at least three branches of biology.

His interest in entomology was centered mainly in the Diptera in which group he was an ardent worker, an extensive contributor and his influence probably second to no other American entomologist.

Aside from his standing in American entomology his host of friends in all branches of science will remember him most affectionately as a man of the finest human qualities and as a striking example of the possibilities of achievement open to the American youth of high ideals and devotion to science.

The Entomological Society of America desires to place on permanent record its appreciation of his earnest and hearty support of the society, his many and valuable contributions to entomology, his standing as a representative of the best in American science and his loyal friendship and manhood.

Committee: HERBERT OSBORN,
T. H. PARKS,
J. J. DAVIS.

SAMUEL WENDELL WILLISTON
Honorary Fellow, Entomological Society of America

Courtesy of Sigma Xi Quarterly

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

The Thirteenth Annual Meeting of the Entomological Society of America was called to order by the Secretary in Room 9, Gilman Hall, Johns Hopkins University, Baltimore, Md., at 1:20 P. M., December 26, 1918.

The President and Vice-Presidents being absent, Dr. T. J. Headlee was elected President pro tem. He appointed the following committees:

AUDITING: H. A. Gossard, G. A. Dean, F. M. Gibson.

NOMINATING: W. E. Britton, W. A. Riley, J. M. Aldrich.

RESOLUTIONS: Herbert Osborn, T. H. Parks, J. J. Davis.

The Chair also appointed the following temporary members of the Executive Committee, to replace absent ones: Jas. G. Needham, E. P. Felt, J. G. Sanders, A. F. Burgess, E. D. Ball.

The meeting then adjourned until 9:00 A. M., December 27.

December 27, 1918.—The meeting was called to order at 9:00 A. M. by President pro tem Headlee, in the same room as before.

The Executive Committee submitted the reports of officers, and the following report of their own:

Your Executive Committee has elected within the year the following members:

On May 1:

PROF. MARIO BEZZI, Turin, Italy.
E. H. BLACKMORE, Victoria, B. C.
E. L. CHAMBERS, Seville, Ohio.
T. N. HUBBELL, Ann Arbor, Mich.
R. F. HUSSEY, Ann Arbor, Mich.
JOS. C. OUELLET, Outremont, Que.
LADISLAV SASKO, Chicago.
FRANK N. WALLACE, Indianapolis, Ind.
WM. LUNDBECK, Copenhagen, Denmark.

On December 26:

O. G. BABCOCK, Dallas, Texas.
A. J. BASINGER, Columbus, Ohio.
H. M. BRUNDRETT, Houston, Tex.
A. N. CAUDELL, Washington, D. C.
A. G. DUSTAN, Fredericton, N. B.
J. E. EYER, Camp Sherman, Ohio.
W. O. HOLLISTER, West Lafayette, Ind.
A. C. KINSEY, Forest Hills, Mass.
H. P. KLOTZ, Woodmere, Long Id.
WM. M. MANN, Washington, D. C.
J. B. PARKER, Washington, D. C.
T. H. PARKS, Columbus, Ohio.
FRED W. POOS, JR., Charlottesville, Va.
THOS. E. B. POPE, Milwaukee, Wis.
MAX H. RUHMANN, Vernon, B. C.
RAYMOND C. SHANNON, (Life Member), Washington, D. C.
RALPH M. SMITH, Twin Falls, Idaho.
OLIVER I. SNAPP, Agr'l College, Miss.
WM. B. TURNER, Hagerstown, Md.
R. H. VAN ZWALENBURG, Hagerstown, Md.
DON C. WARREN, AUBURN, Ala.
L. P. WEHRLE, Ithaca, N. Y.
A. D. WHEDON, West Chester, Pa.

Total, 32.

We have re-elected Herbert Osborn as Managing Editor of the ANNALS, and have elected the following members of the Editorial Board: J. G. Sanders, Wm. M. Wheeler, E. M. Walker, to serve for three years. T. D. A. Cockerell has resigned.

We have re-elected Nathan Banks and A. D. MacGillivray to succeed themselves in the Thomas Say Foundation.

We beg to submit the following recommendations:

First, that in future a time limit of fifteen minutes be placed on papers in our programs, subject to extension by vote of the Society at time of reading.

Second, that one year's dues be remitted to each of our members who has served in the present war in the army or navy of the United States or an allied power; provided, that if such service in any case has been for a longer period than one year, then the remission shall extend to the full period.

Third, that the dues of M. C. Tanquary be remitted for the three years in which he was engaged in Arctic exploration as a member of the Crocker Land Expedition, as a recognition of his gratuitous services to science.

T. J. HEADLEE, *Chairman.*

The report was adopted, including the recommendations.

The accompanying reports were as follows:

REPORT OF THE SECRETARY.

The year's record is distinctly encouraging. Our membership has almost held its own in spite of war; our permanent funds have nearly doubled, including noteworthy gifts from two of our oldest and most honored members; our current income is but slightly below that of last year, which was the largest in our history; and the ANNALS has withstood the rising cost of printing and maintained its high reputation.

The following members have died since the last report:

S. W. WILLISTON, Honorary Fellow.
FREDERICK KNAB, Fellow and charter member.
W. HAGUE HARRINGTON, charter member.
C. A. HART, charter member.
THOMAS P. LUCAS.
VERNON KING, aviator, killed in action.
V. A. E. DAECKE, charter member.

The following have resigned:

H. E. CRAMPTON	F. E. WATSON
M. M. HIGH	M. A. YOTHERS
H. E. SCHRADIECK	S. MARCOVITCH

Thirty-five have been dropped for non-payment of dues.

On Dec. 23rd the membership was in the following classes, as far as the payment of dues is concerned:

(American Members, including Hawaiian.)

Paid for 1918	432
Owing for one year	63
Owing for two years or more	46
(Foreign)	
Paid for 1918	12
Owing for one or more years	20
Total	573
Elected this meeting	21
Actual present membership	594

One year ago I reported 386 members fully paid up, which was probably the highest record for the Society at the time; we now have (counting foreign) 444, which shows how splendidly the members have rallied to our support in war time.

In sending out the annual statements, the Secretary took occasion to suggest that members, nearly all of whom in the United States are now holding bonds of the government, might deposit a fifty-dollar bond in payment for life membership. Four members did this, and two honorary fellows, J. H. Comstock and E. A. Schwarz, each donated a bond of the same amount. Other members indicated an intention, and some a hope, of becoming life members in the near future. It is desirable to keep this matter before the attention of members until after the next loan is subscribed. The result has been encouraging, but should be larger.*

In October, when much of the business of the country was depressed by the wave of influenza, the Secretary received a circular from the Permanent Secretary of the American Association for the Advancement of Science, in which it was announced that the plans of the Association for the Baltimore meeting were much embarrassed, by reason of an unexpected shortage of meeting rooms in Baltimore, the prevailing influenza epidemic, the general war conditions, and the railroad and hotel congestion. This circular suggested that affiliated societies cut down their meetings to the transaction of necessary business and the consideration of problems urgently important for the winning of the war. In view of the fact that the Association of Economic Entomologists, our sister society, might be expected to take care of urgent entomological problems, the Secretary, in transmitting copies of the circular to members of our Executive Committee, took occasion to recommend the abandonment of our program as our logical duty in the premises. The Executive Committee immediately agreed, and announcement was made of this change from our regular policy. Later developments, especially the armistice and the cessation of influenza, so far relieved the situation that I believe we all wish we were to have a program. The decision of the Executive Committee, however, should be viewed from the standpoint of mid-October. No precedent has been established, and the suggestions adopted by our present business session will without doubt operate to give us a better program for next year than we have usually had.

Respectfully submitted,

J. M. Aldrich, *Secretary.*

* Since the meeting E. D. Ball, G. C. Crampton and J. F. Illingworth have become life members.

TREASURER'S REPORT.

Current Account.

RECEIPTS.

Balance on hand (Annals, XI, 101)	$ 303.99
Dues of Members	914.56
From Managing Editor of Annals	485 89
Interest on current account	8.49
Exchange on checks	.40
Total	$1,713.33

DISBURSEMENTS.

Annals for December, 1917	$ 303.51
Engraving for Annals	100.27
Clerical work on Annals	46.80
Printing, Secretary's office	27.25
Postage and stationery, same	23.00
Clerical assistance, same	37.00
One membership diploma	.25
Balance in banks (excluding $2.74 in permanent fund)	1,171.25
Total	$1,713.33

Our present large balance is due to the fact that we have not yet received bills for the last four numbers of the Annals.

Permanent Funds.

On hand last report (Annals, XI, 102)		$273.06
Eugene Amandus Schwarz, gift		50.00
John Henry Comstock, gift		50.00
Wm. T. Davis, life membership		50.00
Howard Notman, life membership		50.00
R. C. Shannon, life membership		50.00
J. M. Aldrich, life membership		50.00
Interest, Cleveland Trust Co.		11 02
Interest on bonds	$3.70	
Less accrued interest paid	1.60	
		2.10
Increase in value of War Savings Stamps since purchase		.40
Total		$586.58

SECURITIES HELD.

Government Bonds—	
First Liberty Loan converted—No. 414,847	$ 50.00
Second Liberty Loan converted—No. 1,784,246	50.00
Third Liberty Loan:	
No. 2,538,965	50.00
No. 2,923,933	100.00
No. 2,923,934	100.00
Fourth Liberty Loan:	
No. 4,714,709	50.00
No. 6,951,394	50.00
No. 490,434	100.00
Total	$550.00
War Savings Stamps, present value, eight Stamps, at $4.23	33.84
Cash to balance, carried in current account	2.74
Total	$586.58

All the permanent funds, it will be noted, have been invested in government securities, except a balance too small to buy a War Savings Stamp.

Respectfully submitted,

J. M. ALDRICH, *Treasurer.*

REPORT OF THE MANAGING EDITOR.

I am happy to report that in spite of the unsettled conditions of the year we have been able to carry the ANNALS through without, we believe, any very vital loss. Aside from delays in the issue of the June and September numbers due to labor conditions, our schedule has been maintained and the volume of 450 pages with an interesting variety of contributions will compare favorably with preceding volumes.

A number of authors deserve our thanks for their generosity in contributing toward the cost of using plates and the printers deserve credit for untiring efforts in the face of many difficulties.

The receipts of this office show a substantial gain over those of last year. The number of outside subscriptions has been somewhat increased and the sale of back numbers and reprints with contributions toward plates giving a favorable balance.

With the return of normal conditions and with a goodly lot of papers already in hand for the next volume, I believe we may feel assured of a good showing for the coming year.

RECEIPTS.

Subscriptions	$275.88
Reprints	138.30
Back Volumes	93 66
Total	$507.84

DISBURSEMENTS.

Stamps and P. O. Deposits	$ 19.70
Work wrapping Annals	2.25
Paid to Treasurer	485.89
Total	$507.84

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

REPORT OF TREASURER OF THOMAS SAY FOUNDATION.

(Copy not on hand at time of going to press.)

This concluded the reports of officers. The reports of the Resolutions, Auditing and Nominating Committees were then presented, as follows:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Your Committee on Resolutions begs to report as follows:

That the Society recognizes with a special sense of loss the death of our lamented honorary fellow, Dr. S. W. Williston, and recommend that a special memorial be prepared for publication in the ANNALS.

That we learn with sorrow of the loss by death of our fellow, Frederick Knab, and of charter members, Chas. A. Hart, W. Hague Harrington, V. A. E. Daecke, and members Vernon P. King and Thomas P. Lucas.

That we desire to accord special praise to those of our members who have courageously served in the war and with profound sorrow the deaths of those who have lost their lives in this service.

That we extend the thanks of the Society to the officers of Johns Hopkins University for the privileges afforded in connection with meeting places and other favors during the present meeting.

HERBERT OSBORN,
T. H. PARKS,
J. J. DAVIS.

REPORT OF AUDITING COMMITTEE.

Dec. 26, 1918.

Your Committee has examined the records, vouchers and property reported by Secretary-Treasurer J. M. Aldrich and Editor Herbert Osborn of the ANNALS, and find the same to be correct and properly kept.

H. A. GOSSARD,
GEO. A. DEAN,
FRANK M. GIBSON.

REPORT OF NOMINATING COMMITTEE.

The Nominating Committee beg leave to nominate the following officers for the coming year:

President—JAS. G. NEEDHAM.

First Vice-President—J. W. FOLSOM.

Second Vice-President—R. V. CHAMBERLIN.

Secretary-Treasurer—J. M. ALDRICH.

Additional Members Executive Committee—F. E. LUTZ, ARTHUR GIBSON, G. A. DEAN, G. C. CRAMPTON.

Respectfully submitted,

H. A. GOSSARD,
W. A. RILEY,
J. M. ALDRICH.

On motion, the report of the Nominating Committee was adopted, and the Secretary instructed to cast the ballot of the Society for the officers nominated; which being done, the President pro tem declared them duly elected.

Under general business, Dr. Headlee moved that it is the sense of the meeting that each annual program should have one session devoted to a symposium on some general entomological topic. Seconded and carried.

Professor W. A. Riley proposed an amendment to the Constitution, which was allowed to lie upon the table until the next annual meeting, as required by the Constitution.

At 10:05 A. M. the meeting adjourned.

J. M. ALDRICH, Secretary.

ANNALS

OF

The Entomological Society of America

Volume XII JUNE, 1919 Number 2

THE OLFACTORY SENSE OF LEPIDOPTEROUS LARVÆ.

N. E. McIndoo, Ph. D.,
Insect Physiologist, Deciduous Fruit Insect Investigations,
Bureau of Entomology, Washington, D. C.

INTRODUCTION.

A thorough investigation of the above subject will undoubtedly throw some light upon how plants attract insects, because as yet no one has shown experimentally that lepidopterous larvæ can smell and the olfactory organs have never been described. Whenever it is proved that insect larvæ respond to chemical stimuli, and whenever organs suitable for the reception of these stimuli have been found, then we can intelligently ask why do the cotton caterpillar (*Alabama argillacea* Hübr.) and cotton boll weevil (*Anthonomus grandis* Boh.) feed exclusively on the cotton plant?; or why does the silkworm (*Bombyx mori* L.) feed almost exclusively on mulberry-tree leaves?. Many more similar examples could be given by any entomologist, but why is it that some larvæ are very selective in regard to their food while others show little or no preference between members of a large list of plants. Also, how does a female lepidopteron distinguish the best or only suitable host plant for her progeny so that she can deposit her eggs on this particular plant? The only plausible answer for all of these questions is to suppose that plants, as well as animals, emit odors, and that insects in searching for food, either for themselves or for their young progeny, are guided by the odors emitted by the plants. In order that the odors of plants may differ, it may also be assumed that the various chemical constituents of plants emit particular odors and that the odor emitted from a plant may be a combination of all the odors from the various constituents, or possibly one odor might be so strong that it masks all the others.

Upon this hypothesis, the odors from plants would vary according to the number, combination and quantitative percentages of the various constituents. Reasoning along this line of thought, we may be able to explain why a few insects have only one host plant; why many have a preferred host plant, but will eat other allied plants; and why others eat a large number of plants. If we could positively answer the above questions, we might be able to devise practical methods for the control of certain insects, as by trap baits, etc.

The present investigation will show that lepidopterous larvæ respond to chemical stimuli and that they have organs suitable for receiving these stimuli; and the following review of the literature will indicate how insects are attracted by certain host plants.

Verschaffelt (1910), experimenting with the cabbage-butterfly larvæ, *Pieris brassicæ* and *P. rapæ*, found that they are very fond of the cultivated species of the Cruciferæ and that in captivity they ate leaves from 15 indigenous species, representing 14 genera, of the same family. They did not eat all of these species, however, equally readily, and refused to eat species belonging to 17 other families, but did attack *Tropæolum* and *Reseda* which belong to two other families. Chemists have determined that all of the plants eaten by the above larvæ contain mustard oils. To determine whether these larvæ could be induced to eat leaves not ordinarily attacked, leaves of *Apios tuberosa* were smeared with the juice from the leaves of a crucifer (*Bunias orientalis*); these leaves were at once attacked and in a short time devoured. Wheat flour and corn starch, which when dry or moistened with water are rejected by both *Pieris-larvæ*, are eaten with avidity when soaked with *Bunias*-juice. The larvæ behave in a similar manner toward filter paper saturated with *Bunias*-juice.

To ascertain the exact constituent in the plants and juices which attracted the larvæ, Verschaffelt wet leaves of *Apios tuberosa* and *Rosa* (two species not containing mustard oil) with a fairly strong solution of pure sinigrin (potassium myronate), the glucoside of black mustard; these leaves were eagerly eaten by the larvæ. He says: "It is clear that *Pieris*-caterpillars seek out various mustard oils, just like the various glucosides derived from them. They are clearly attracted by the whole group of substances."

RESPONSE TO CHEMICAL STIMULI.

While feeding silkworms it is easy to determine that they can smell; this is done by placing fresh mulberry-tree leaves near them so that they can neither see nor touch the leaves; immediately the silkworms move their heads, work their mouth parts and begin crawling toward the leaves, and sometimes a hungry silkworm for several minutes will follow a leaf dragged slowly just in front of its head and the writer believes that the larva is guided solely by means of the odors emitted from the leaf rather than by seeing the leaf. Silkworms may also be induced to eat other leaves which they will not ordinarily even "taste." This was proved by the following test: Leaves from peach trees, cherry trees, plum trees, and apple trees were dipped into the juice from mulberry-tree leaves and were then fed wet to silkworms; all of these leaves were eaten, although some of them apparently were not really relished. When other leaves of the same trees were dipped into water, the silkworms did not even "taste" them.

To test the responses to other chemical stimuli the various larvæ used were confined in small observation cases and the sources of the odors were usually kept in small vials which were held directly beneath the larva in the case. The following larvæ were used in the experiments: Tent caterpillars, fall webworms, tussock-moth larvæ, army worms and larvæ of a butterfly (*Papilio polyxenes*). The following sources of odors were employed and the average reaction time of the above larvæ to them are: Oil of peppermint, 14.6 seconds; oil of thyme, 9.5 seconds; oil of wintergreen, 17.6 seconds; dried leaves of pennyroyal, 20.1 seconds; dried leaves of spearmint, 22.9 seconds; wild cherry-tree leaves, 42.5 seconds; fresh grass, 19.1 seconds, old honey and comb, 51.5 seconds; protruded thoracic glands of above Papilio larvæ, 22.8 seconds; and as a control—a clean and empty vial, 60 seconds (totally negative). The details pertaining to these experiments are as follows:

In each set of experiments 10 larvæ were used, one larva being confined in a case. As a rule, the more the larvæ were handled the more satisfactorily they responded to odors, but generally speaking these larvæ were the most unfavorable insects that the writer has ever used for testing the responses to odors. When placed in the experimental cases, all of them,

except the army worms, had the habit of crawling into the corners and lying there more or less dormant and in such a position would never respond to odors; therefore, before testing a larva it was first necessary to see that it was lying flat on the bottom of the case, and in order to insure, if possible, a response to another odor after an interval of 15 minutes, it was usually touched with a pencil to "awaken it from its stupor." Caterpillars in their webs rarely responded to the odors used. The following records include only the first responses and their reaction times.

MEDIUM SIZED TENT CATERPILLARS (*Malacosoma americana* Fab.).

Oil of peppermint:
6 moved head slightly. 1 raised head and crawled away.
1 moved away slowly. 1 moved head and worked mouth parts.
1 raised head quickly.
Reaction time 3 to 15 seconds, average 7.5 seconds.

Oil of thyme:
6 moved head slightly. 1 raised head and moved away slowly.
3 moved away slowly.
Reaction time 3 to 15 seconds, average 5.4 seconds.

Oil of wintergreen:
5 moved head slightly. 2 raised head and moved away slowly.
2 showed no response. 1 moved away slowly.
Reaction time 4 to 60 seconds, average 20.6 seconds. In all cases 60 seconds was regarded totally negative.

Dried leaves of pennyroyal:
5 moved away slowly. 1 moved head sidewise.
3 moved head slightly. 1 showed no response.
Reaction time 3 to 60 seconds, average 22.2 seconds.

Dried leaves of spearmint (odor very weak):
5 showed no response. 2 moved head slightly.
2 moved away slowly. 1 moved leg back and forth.
Reaction time 5 to 60 seconds, average 38.3 seconds.

Wild cherry tree leaves cut into small pieces (their favorite food):
4 showed no response. 1 moved away slowly.
4 moved head slightly. 1 raised head slowly.
Reaction time 5 to 60 seconds, average 42.5 seconds.

Old honey and comb (odor very faint):
6 showed no response. 4 moved head slightly.
Reaction time 20 to 60 seconds, average 51.5 seconds.

Empty and odorless vial (used as a control):
10 showed no response.

SMALL FALL WEBWORMS (*Hyphantria cunea* Dru.)

Oil of peppermint:
3 moved slightly. 1 moved head sidewise.
2 raised head and thorax quickly. 1 turned around.
2 worked mouth parts. 1 raised head.
Reaction time 2 to 40 seconds, average 11.8 seconds.

Oil of thyme:
4 raised head quickly.
3 moved head and worked mouth parts.
1 moved slightly.
1 moved away quickly.
1 raised thorax quickly.
Reaction time 2 to 10 seconds, average 4.5 seconds.

Oil of wintergreen:
3 moved head slightly.
2 raised head quickly.
2 moved away quickly.
1 worked mouth parts.
1 moved head sidewise.
1 raised head and thorax slowly.
Reaction time 2 to 30 seconds, average 7.5 seconds.

Dried leaves of pennyroyal:
5 moved slightly.
2 raised head and thorax slowly.
1 moved away slowly.
1 moved head slightly.
1 moved head and thorax sidewise and bit wire-screen bottom of case.
Reaction time 2 to 25 seconds, average 7.4 seconds.

Dried leaves of spearmint (odor very weak):
4 moved slightly.
2 raised head quickly.
1 moved slightly.
2 moved away quickly.
1 moved head slightly.
Reaction time 3 to 15 seconds, average 6.4 seconds.

LARGE TUSSOCK-MOTH LARVAE (*Hemerocampa leucostigma* S. and A.)

Oil of peppermint:
6 moved slightly.
2 moved away.
1 showed no response.
1 raised head and thorax quickly.
Reaction time 2 to 60 seconds, average 17.3 seconds.

Oil of thyme:
8 moved slightly.
1 raised head.
1 showed no response.
Reaction time 2 to 60 seconds, average 13.1 seconds.

Oil of wintergreen:
3 raised head.
2 moved slightly.
2 jerked head backward.
1 moved head sidewise.
1 moved away slowly.
1 showed no response.
Reaction time 2 to 60 seconds, average 16.3 seconds.

Dried leaves of pennyroyal:
4 moved away slowly.
3 moved slightly.
2 raised head.
1 showed no response.
Reaction time 2 to 60 seconds, average 23.2 seconds.

Dried leaves of spearmint (odor very weak):
6 moved away.
2 moved slightly.
2 showed no response.
Reaction time 5 to 60 seconds, average 30 seconds.

Protruded thoracic glands of larvæ (*Papilio polyxenes*).
5 moved slightly.
2 moved away slowly.
2 showed no response.
1 raised head.
Reaction time 2 to 60 seconds, average 22.8 seconds.

LARGE ARMY WORMS (*Cirphis unipuncta* Haw.)

Oil of peppermint:
5 raised head quickly.
2 raised head slowly.
3 raised head quickly and waved it sidewise.
Reaction time 2 to 5 seconds, average 2.9 seconds.

Oil of thyme:
4 raised head quickly and moved sidewise.
3 raised head quickly.
3 raised head slowly.
Reaction time 2 to 5 seconds, average 2.5 seconds.

Oil of wintergreen:
5 raised head quickly and moved it sidewise.
2 raised head quickly and moved backward.
2 raised head slowly.
1 raised head quickly.
Reaction time 2 to 10 seconds, average 2.9 seconds.

Dried leaves of pennyroyal:
8 raised head slowly.
1 raised head quickly.
1 moved away slowly.
Reaction time 2 to 10 seconds, average 4.2 seconds.

Dried leaves of spearmint (odor very weak):
6 raised head slowly.
3 raised head quickly.
1 raised head slowly and waved it sidewise.
Reaction time 2 to 4 seconds, average 2.7 seconds.

Fresh grass in vial (food of these larvæ):
2 raised head slowly.
2 moved slightly.
2 showed no response.
2 moved backward slowly.
1 moved forward quickly.
1 raised head and bit screen-wire bottom of case.
Reaction time 2 to 60 seconds, average 19.1 seconds.

BUTTERFLY LARVAE (*Papilio polyxenes* Fab.)

Oil of peppermint:
5 raised head.
5 showed no response.
Reaction time 3 to 60 seconds, average 33.2 seconds.

Oil of thyme:
5 raised head.
2 moved quickly.
2 showed no response.
1 moved caudal end of body.
Reaction time 2 to 60 seconds, average 22.1 seconds.

Oil of wintergreen:
5 moved slightly.
5 showed no response.
Reaction time 7 to 60 seconds, average 40.7 seconds.

Dried leaves of pennyroyal:
4 showed no response.
3 raised head.
3 moved slightly.
Reaction time 10 to 60 seconds, average 43.5 seconds.

Dried leaves of spearmint (odor very weak):
5 showed no response.
3 raised head.
2 moved slightly.
Reaction time 3 to 60 seconds, average 37.3 seconds.

In comparing the preceding reaction times, no conclusion can be drawn in regard to the comparative sensitiveness of the five species tested, because the responses depended more on the behavior of the larva tested than on its ability to perceive chemical stimuli. Of the five species used, only the army worms were favorable for experimental purposes; these were usually active, never failed to respond when tested, and the responses were generally quick and pronounced ones. Of the five species used, the butterfly larvæ were the most sluggish and their reaction times are the slowest of all.

MORPHOLOGY OF OLFACTORY PORES OR PUNCTURES.

The preceding pages show that lepidopterous larvæ respond to chemical stimuli, and the following pages will show that these larvæ have organs suitable for the reception of chemical stimuli, but no experiments were performed to determine the function of these organs which were first called olfactory pores by the writer (1914a). The same type of organs seems to be common to all adult insects and the writer has proved experimentally that they receive chemical stimuli in Hymenoptera (1914b) and Coleoptera (1915). They have also proved to be common to all of the coleopterous and lepidopterous larvæ yet examined by the writer, and now for several years systematists have known them in lepidopterous larvæ as "punctures." The writer (1918) has recently described the external and internal anatomy of them in a coleopterous larva of the 'fig-eater,' *Allorhina* (*Cotinis*) *nitida* L.

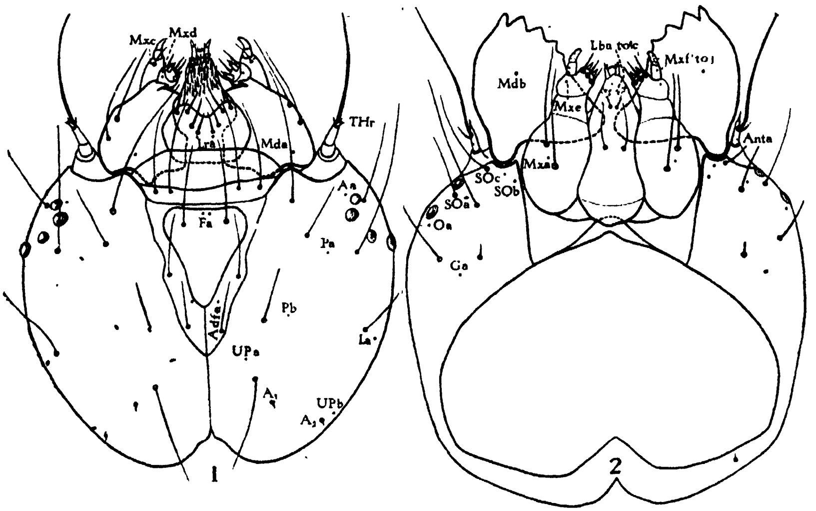
1. Disposition of Pores or Punctures.

In making a comparative study of the distribution and number of these pores in lepidopterous larvæ, 30 species, belonging to 28 genera and representing 20 families have been used. Most of these were collected by the writer and the remainder were kindly furnished by Mr. Carl Heinrich who identified all of them. With a few exceptions, the writer has adopted Mr. Heinrich's (1916, 1918) nomenclature given to most of the punctures present on the head capsule and at the suggestions of Messrs. Heinrich and Busck he has formulated new names for those pores not already named. The various parts of the anatomy on which these pores occur were verified by Dr. Adam Böving; the three foregoing mentioned men also belong to the Bureau of Entomology.

In most cases only one specimen of each species was examined, and consequently, owing to unfavorable mounts and the lack of sufficient material, the total number of pores recorded can not be regarded as accurate. Since the army worm was the most favorable material at hand, several specimens of it were treated with caustic potash and the pores on it have been studied and drawn in detail.

The description of them will be given first and then will follow a brief account of those in other species.

Army Worm: Upon examining the head capsules of lepidopterous larvæ under a low-power lens, several minute circular light spots were seen; these spots resemble hair sockets from which the hairs have been removed, but former studies dealing with similar spots at once suggested that they might be the olfactory pores, so common to adult insects and coleopterous larvæ. Upon examining them under a high-power lens, it was soon observed that their external anatomy is different from that of hair sockets and sections through them proved that they are really olfactory pores.



FIGS. 1 AND 2.—Disposition of the pores or punctures and setæ on the head of a small army worm (*Cirphis unipuncta* Haw.), only the pores being here named, × 20. Fig. 1, dorsal view and Fig. 2, ventral view. Frontal pore (*Fa*); adfrontal pore (*Adfa*); anterior pore (*Aa*); posterior pores *a* (*Pa*) and *b* (*Pb*); lateral pore (*La*); ultraposterior pores *a* (*UPa*) and *b* (*UPb*); labral pore (*Lra*); mandibular pores *a* (*Mda*) and *b* (*Mdb*); maxillary pores *a* (*Mxa*), *c* (*Mxc*), *d* (*Mxd*), *e* (*Mxe*), and *f* to *j* (*Mxf* to *j*); labial pores *a* to *c* (*Lba* to *c*); antennal pore (*Anta*); genal pore (*Ga*); ocellar pore (*Oa*); subocellar pores *a* (*SOa*), *b* (*SOb*) and *c* (*SOc*); secondary setæ (A_1 and A_2); and Nagel's so-called olfactory pegs on antennæ (*THr*).

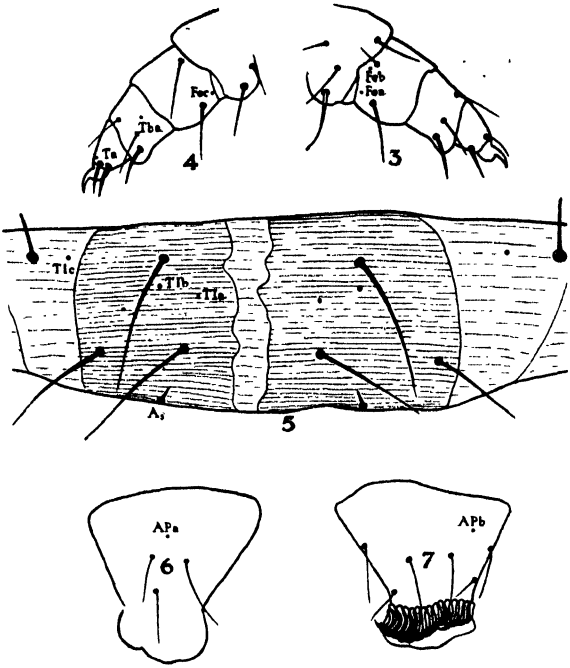
Referring to Figures 1 and 2, it is seen that they are always paired and they are located and named as follows: On the front: the frontal pore (*Fa*); on the adfrontal piece: the adfrontal pore (*Adfa*); on the dorsal sureface of the epicranium: the anterior pore (*Aa*), posterior pores *a* (*Pa*) and *b* (*Pb*), lateral pore (*La*), and ultraposterior pores *a* (*UPa*) and *b* (*UPb*); on the ventral surface of the epicranium: the genal pore (*Ga*),

ocellar pore (*Oa*), and subcellar pores *a* (*SOa*), *b* (*SOb*) and *c* (*SOc*); on the dorsal and ventral surfaces, respectively, of the mandible: the mandibular pores *a* (*Mda*) and *b* (*Mdb*); on the ventral surface of the labium: the labial pores *a*, *b* and *c* (*Lba* to *c*); and on the dorsal surface of the labrum: the labral pore (*Lra*). Relative to the maxilla they are as follows: On the ventral surface of the stipes: the maxillary pore *a* (*Mxa*); on the dorsal surfaces of the palpiger, first segment of the maxillary palpus and maxillary lobe, respectively: the maxillary pores *b*, *c* and *d* (Fig. 8, *Mxb* to *d*); on the ventral surfaces of the first, second and third segments of the maxillary palpus, respectively: the maxillary pores *e* (Fig. 2, *Mxe*) and *f* to *j* (*Mxf* to *j*). On the ventral surface of the second or terminal segment of the antenna, near the proximal end at the outer side, lies the antennal pore (*Anta*).

Relative to the thorax and abdomen, the pores are located and may be named as follows: On the anterior surface of the femur: the femoral pores *a* and *b* (Fig. 3, *Fea* and *Feb*); on the posterior surface of the femur: the femoral pore *c* (Fig. 4, *Fec*); on the posterior surfaces of the tibia and tarsus, respectively: the tibial pore (Fig. 4, *Tba* and tarsal pore (*Ta*); on the tergum of the prothorax: the thoracic pores *a*, *b* and *c* (Fig. 5, *TIa* to *c*); on the tergum of the last abdominal segment: a single pair of pores, the abdominal pores (not drawn); and on the dorsal and ventral surfaces, respectively, of the anal proleg: the anal-proleg pores *a* and *b* (Figs. 6 and 7, *APa* and *APb*).

Relative to the pores on the head of the army worm, the subocellar pores (Fig. 2, *SOb* and *SOc*) and mandibular ones (*Mdb*) are the most difficult to be found. While the former lie in almost transparent chitin, the latter one lies in very dark chitin; all of these, as well as the pair (Fig. 1, *Mda*) on the dorsal side of the mandibles, seem to have been overlooked by other observers. The ultraposterior ones (Fig. 1, *UPa* and *UPb*) are easily mistaken for the secondary setæ (A_1 and A_2) and can only be distinguished from them by aid of a high-power lens. Perhaps all of the pores on the labium and maxillæ have been seen by systematists, but it seems that the third labial pair (Figs. 2 and 20, *Lbc*), and maxillary pores *b*, *g* to *j* (Figs. 8 and 9, *Mxb*, *g* to *j*) have never been drawn. As far as known to the writer, those on the legs, last abdominal segment and on the anal prolegs are here reported for the first time.

The location and total number of the pores on various parts of the army worm are as follows: front, 2; adfrontal piece, 2; epicranium, 22; antennæ, 2; mandibles, 4; labium, 6; labrum, 2; maxillæ, 20; trochanters, 18; tibiæ, 6; tarsi, 6; prothorax, 6; last abdominal segment, 2; and anal prolegs, 4; making 102 pores in all.



Figs. 3 to 7.—Disposition of pores or punctures on leg, first thoracic segment and on anal proleg of a small army worm, × 20. Figs. 3 and 4, anterior and posterior surfaces, respectively, of left prothoracic leg. Fig. 5, most of tergum of prothorax; the shield or strongly pigmented stripes are more heavily shaded than are the lightly pigmented portions. Figs. 6 and 7, dorsal and ventral surfaces, respectively, of same anal proleg. Femoral pores *a* (*Fea*), *b* (*Feb*) and *c* (*Fec*); tibial pore (*Tba*); tarsal pore (*Ta*); thoracic pores *a* (*TIa*), *b* (*TIb*) and *c* *TIc*); anal-proleg pores *a* (*APa*) and *b* (*APb*); and secondary seta (A_3).

Other species. The integuments of other species examined were not studied as critically as were those of the army worm, and consequently, some of the pores have certainly been overlooked, particularly the ones most difficult to be found. Some of the preparations had to be bleached with chlorine gas before they could be studied, but most of them were so light in color that it was difficult to find some of the pores, and the butterfly

larvæ were the least favorable of all, owing to their almost total lack of pigment and to the fact that the hairs on the epicranium arise from large tubercles.

The following table gives the larger variations concerning the disposition of these pores and now the smaller variations may be briefly stated. For sake of brevity, instead of using the long scientific names of the larvæ examined, the species will be numbered from 1 to 30, and those interested in associating the names of the species with the variations described may do so by referring to the names and numbers of the species in the table on page 76. For each of the 30 species examined, the pores are constant in number on the following parts of the integument: Front, 2; each antenna, 1; each stipes, 1; each maxillary lobe, 1; each second segment of the maxillary palpus, 1; and each third or terminal segment of the maxillary palpus, 4. The number of pores found on the epicranium (including the adfrontal piece) varies as follows: On each of 14 species, 10 pores (Nos. 1, 3, 6, 10, 12, 14, 16–18, 21, 24, 25, 29, 30); on each of 4 species, 12 pores (Nos. 2, 4, 5, 22); on each of 9 species, 14 pores (Nos. 9, 11, 13, 15, 19, 20, 23, 27, 28); on each of 2 species, 18 pores (Nos. 7, 26); and on 1 species, 24 pores (No. 8, the army worm).

If all of the pores on each epicranium had been found, perhaps 20 would be a common number for nearly all of the species. One pore was found on each mandible of 29 species, but had this appendage been examined more carefully two pores might have been found on each mandible as already shown for the army worm. The number of pores found on the labium varies as follows: On each of 12 species, 4 pores (Nos. 1, 12, 13, 15–21, 23, 26); and on each of 18 species, 6 pores (Nos. 2–11, 14, 22, 24, 25, 27–30). The number of pores found on the labrum varies as follows: On each of 5 species, 2 pores (Nos. 7–10, 16); on each of 11 species, 4 pores (Nos. 6, 11, 14, 17–19, 21, 23, 25–27); and on each of 14 species, 6 pores (Nos. 1–5, 12, 13, 15, 20, 22, 24, 28–30). The first segment of each maxillary palpus has 1 pore, except 2 were found on each one of 4 species (Nos. 3–5, 8). Three pores were found on each femur, except 2 on each one of 10 species (Nos. 14, 15, 17–19, 21, 22, 24, 25, 29). One pore was found on each tibia, except 2 pores on each of 1 tibia of 2 species (Nos. 9, 14) and 3 pores on 1 tibia of 1 species (No. 30). One pore was found on each tarsus, except

TABLE I.

Disposition of the pores or punctured found on *lepidopterous larvæ.*

Family and Number and Name of Species	Number of Pores on: Head — Head capsule	Head — Head appendages	Thorax — Legs	Thorax — First thoracic segment	Abdomen — Last segment and anal prolegs	Total No. of pores found
SPHINGIDÆ—						
1. *Phlegothontius sexta* Joh	12	30	30	...	...	72
2. *Ceratomia catalpæ* Bvd	14	32	30	...	...	76
SATURNIIDÆ—						
3. *Antomeris io* Fab	12	36	30	...	...	78
ARCTIIDÆ—						
4. *Hyphantria cunea* Dru	14	34	30	...	...	78
NOCTUIDÆ—						
5. *Apatela(Acronycta)americana*Harr	14	34	30	...	1	79
6. *Prodenia ornithogalli* Guen	12	30	30	...	...	72
7. *Feltia* sp	20	28	30	6	2	86
8. *Cirphis unipuncta* Haw	26	34	30	6	6	102
NOTODONTIDÆ—						
9. *Datana integerrima* G. & R	16	28	31	3	...	78
10. *Datana ministra* Dru	12	28	30	2	...	72
LIPARIDÆ—						
11. *Hemerocampa leucostigma* S.& A.	16	30	30	...	...	76
LASICAMPIDÆ—						
12. *Malacosoma americana* Fab	12	30	30	2	2	76
BOMBYCIDÆ—						
13. *Bombyx mori* L	16	30	30	...	3	79
GEOMETRIDÆ—						
14. *Alsophila pometaria* Harr	12	30	19	...	...	61
PSYCHIDÆ—						
15. *Thyridopteryx ephemeræformis* Haw	16	30	18	...	...	64
COCHLIDIIDÆ—						
16. *Sibine stimulea* Clem	12	26	30	...	...	68
MEGALOPYGIDÆ—						
17. *Lagoa crispata* Pack	12	28	24	...	...	64
18. *Megalopyge opercularis* S. & A.	12	28	24	...	...	64
ZYGÆNIDÆ—						
19. *Harrisina americana* Guér-Mén	16	28	24	...	...	68
PYRALIDÆ—						
20. *Diatræa saccharalis* Fab	16	30	30	4	...	80
21. *Achroia grisella* Fab	12	28	24	...	...	64
22. *Dioryctria abeitella* D. & S	14	32	24	4	1	75
OLETHREUTIDÆ—						
23. *Laspeyresia pomonella* L	16	28	30	3	1	78
24. *Laspeyresia molesta* Busck	12	32	24	2	...	70
YPONOMEUTIDÆ—						
25. *Atteva aurea* Fitch	12	30	24	...	...	66
GELECHIIDÆ—						
26. *Pectinophora gossypiella* Saund	20	28	30	2	...	80
BLASTOBASIDÆ—						
27. *Valentinia glandulella* Riley	16	30	30	2	...	78
PAPILIONIDÆ—						
28. *Papilio polyxenes* L	16	32	30	...	...	78
PIERIDÆ—						
29. *Pontia rapæ* L	12	32	24	...	...	68
NYMPHALIDÆ—						
30. *Basilarchia archippus* Cram	12	32	32	...	...	76
Variation:	12-26	26-36	18-32	0-6	0-6	61-102

none on the tarsi of 2 species (Nos. 14, 15). The number of pores found on the first thoracic segment varies as follows: Six on each of 2 species (Nos. 7, 8); 4 on each of 2 species (Nos. 20, 22); 3 on each of 2 species (Nos. 9, 23); and 2 on each of 5 species (Nos. 10, 12, 24, 26, 27). Two pores were found on each of the last abdominal segment of 3 species (Nos. 7, 8, 13). The number of pores on both anal prolegs varies as follows: One for each of 3 species (Nos. 5, 22, 23); 2 for each of 2 species (Nos. 12, 13); and 4 for the army worm (No. 8).

The total number of pores found varies from 61 to 102, but no conclusion in regard to the comparative sensitiveness of the various species can be drawn, owing to the fact that only one of the species listed was critically studied.

In these examinations no attention has been paid to the size or age of the larva being examined and at first thought one might think that the disposition of the pores would vary according to the instars, but Mr. Busck informs me that he has found no such variations.

Discussion. According to the earlier papers concerning lepidopterous larvæ, some of the entomologists have observed the more conspicuous pores on the heads of these larvæ; they have called these organs sensory pits and punctures, but knew nothing about their internal anatomy. Within the past few years, systematists have been making comparative studies of the setæ and punctures present on the integuments of lepidopterous larvæ and have used these characters successfully for classifying the larvæ.

Forbes (1910) seems to have presented the first comparative paper on this subject. He appears to have found some punctures on all of the larvæ examined; he has mapped the frontal punctures on 33 species and adfrontal ones on 28 species, but represents only a few of those present on the epicranium and mouth parts. The same author (1911) mapped 3 pairs of punctures on the labrum each of 4 sphingids.

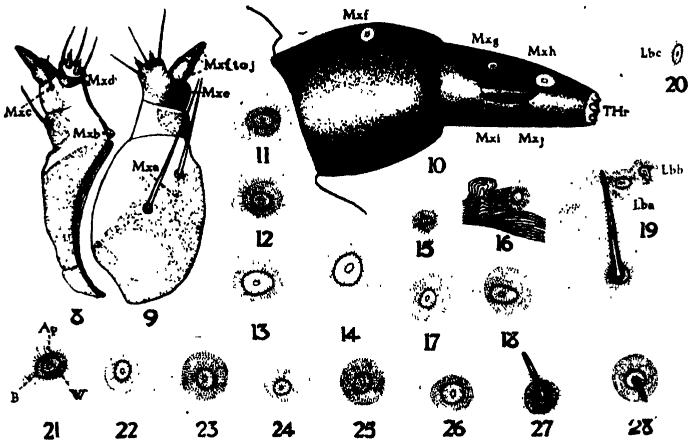
Tsou (1914) mapped 2 pairs of punctures on the dorsal surface of the prothorax of two genera.

Fracker (1915) mapped the frontal and adfrontal punctures of several species.

Heinrich (1916) named and mapped most of the punctures present on the head capsule of a micro-lepidopteron, and the

same author (1918) continued this study using the genus *Opostega*.

Busck (1917) mapped most of the punctures present on the head capsules of the pink bollworm (*Pectinophora gossypiella* Saund.) and the scavenger bollworm (*Pyroderces rileyi* Wals.). He found 22 punctures on each capsule, while the present writer found 20 on the former capsule; in all probability there are 26 on each capsule.



FIGS. 8 TO 28.—Disposition and external view of pores or punctures on same army worm as represented in Figs. 1 to 7. Figs. 8 and 9, disposition of pores on dorsal and ventral surfaces, respectively, of left maxilla, × 50. Maxillary pores *a* to *j* (*Mxa* to *j*). Figs. 10 to 28, external structures of pores and setæ, × 320. Fig. 10, ventral surface of second and third segments of maxillary palpus, showing maxillary pores *f* to *j* (*Mxf* to *j*) and tactile hairs (*THr*) at tip of palpus. Fig. 11, tibial pore; Fig. 12, thoracic pore *c;* Fig. 13, abdominal pore; Fig. 14, anal-proleg pore *b;* Figs. 15 and 16, maxillary pores *d* and *b*, respectively; Fig. 17, labral pore; Fig. 18, mandibular pore *a;* Figs. 19 and 20, labial pores *a* to *c*, drawn in proper relation to each other; Fig. 21, frontal pore; Fig. 22, adfrontal pore; Fig. 23, lateral pore; Fig. 24, subocellar pore *c;* Fig. 25, ultraposterior pore *b;* Fig. 26, antennal pore; Fig. 27, secondary seta (Fig. 5, A_1) on prothorax; and Fig. 28, secondary seta (Fig. 1, A_2) on head. Pore aperture (*Ap*); pore border (*B*); and pore wall (*W*).

2. *External Anatomy of Pores or Punctures.*

Under a high-power lens it is observed that a pore usually has a dark border (Fig. 21, *B*) which may be round, oblong or occasionally almost diamond-shaped, and it may show indications of radial streaks. Inside the border lies the wall (*W*) which is usually dark and heavy; it is the most conspicuous part of the organ and may be round or oblong. Inside the wall the chitin is lighter in color and at the center may be seen an

aperture (*Ap*) which appears as a transparent spot; the aperture is a minute opening passing through the thin chitin inside the wall.

Sometimes it is almost impossible to distinguish a secondary seta from a pore, but in almost all cases the chitin inside the wall of such a seta is lighter in color than that inside the wall of a pore, and this fact may help to distinguish a seta from a pore in case the seta has been pulled out; this comparison may be seen by referring to Figures 25 and 28, both of which structures come from the same region on the epicranium.

In size the pores do not vary greatly, as may be observed by looking at Figures 10 to 28. The smallest one (Fig. 10, *Mxj*) lies on the terminal segment of the maxillary palpus and the largest one (Fig. 14) in the army worm lies on the anal proleg; the former is scarcely discernible and seldom has a border. The one (Fig. 10, *Mxi*) nearest it is always slit-shaped and also in some species can scarcely be seen. The other two (*Mxg* and *Mxh*) on this segment are easily seen in good mounts, and have distinct borders.

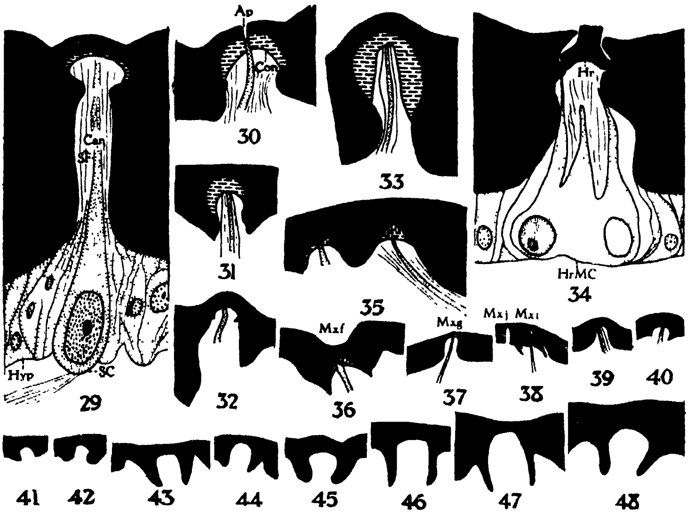
3. *Internal Anatomy of Pores or Punctures.*

A reference to Figures 29 to 48 shows that the internal structure of these organs is like that of those in other insects, and consequently only a brief description of the various parts of them will suffice here. Lying in the thick hypodermis (Fig. 29, *Hyp*) is the large sense cell (*SC*) whose peripheral end (*SF*) passes through the pore canal (*Can*), pierces the chitinous cone (Fig. 30, *Con*) and then stops in the bottom of the pore aperture (*Ap*) where it seems to come in direct contact with the external air. The chitin covering the cone may be dome-shaped, with the dome either lying in a depression (Fig. 29) or elevated above the surrounding chitin(Fig. 33); or it may form a depression whose bottom is pierced by the pore aperture (Fig. 36); or it may lie on the same level with the surrounding chitin (Fig. 31).

Since the chitin was so thick, not a single section showed all the details of one of these organs, because the microtome knife never passed properly through the structure; but Figures 29 and 30 combined give a good idea of their anatomy, which is very different from the internal anatomy of a large hair (Fig. 34) which is formed by a large hair-mother cell (*HrMC*) sending

forth processes through the pore canal to the base of the hair (*Hr*). Should both the base of the hair and the hair-mother cell be missing, the hair socket itself in sections serves well to distinguish this structure from a pore.

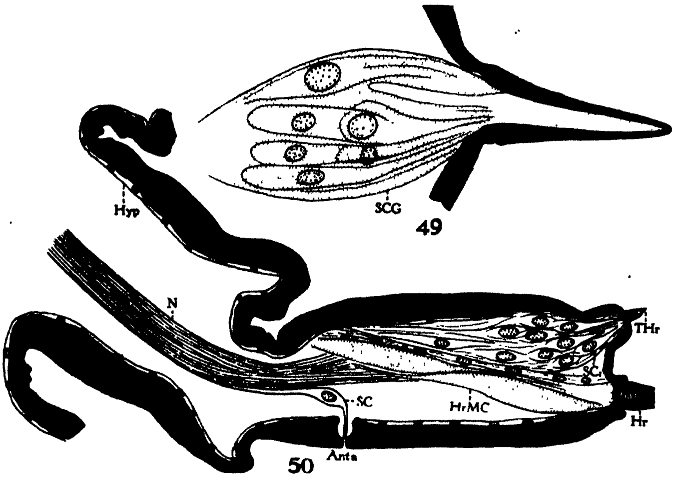
To determine whether all of the structures recorded as pores are really pores or hair sockets, thin sections made through the various parts of the integuments bearing these structures were



FIGS. 29 TO 48.—Sections, showing internal anatomy of pores or punctures and of one hair from various lepidopterous larvæ, × 500. Figs. 29, 31 to 34 are pores from *Ceratomia catalpæ*; Fig. 29, being from epicranium; Fig. 31, from antenna; Fig. 32, from palpiger; Fig. 33, from labium; and Fig. 34 is internal structure of a large hair on epicranium. Fig. 30 is a pore from labrum of *Telea polyphemus* and Fig. 35, two pores from labrum of silkworm (*Bombyx mori*). Figs. 36 to 38, maxillary pores *f* (*Mxf*), *g* (*Mxg*), *j* (*Mxj*) and *i* (*Mxi*), respectively, of tomato worm *Phlegothontius sexta*). Fig. 39, pore from labrum and Fig. 40, pore from antenna of cabbage-butterfly larva (*Pontia rapæ*). Figs. 41 to 48, sections from material, treated with caustic potash. Fig. 41, pore from terminal segment of maxillary palpus of codling moth (*Laspeyresia pomonella*). Figs. 42 to 48, pores from army worm (*Cirphis unipuncta*); Fig. 42, from tibia; Fig. 43, from antenna; Fig. 44, from maxillary lobe; Fig. 45, from femur; Fig. 46, from mandible; Fig. 47, from front; and Fig. 48, from anal proleg. Sense cell (*SC*); hypodermis (*Hyp*); sensory fiber (*SF*); pore canal (*Can*); chitinous cone (*Con*); pore aperture (*Ap*); hair-mother cell (*HrMC*); and base of hair (*Hr*).

carefully studied; in every case the suspected pore proved to be a real pore. Since most of these are so scattered, they are easily overlooked in sections made from fixed material, but were found much more easily in sections made from material treated with caustic potash (Figs. 41 to 48).

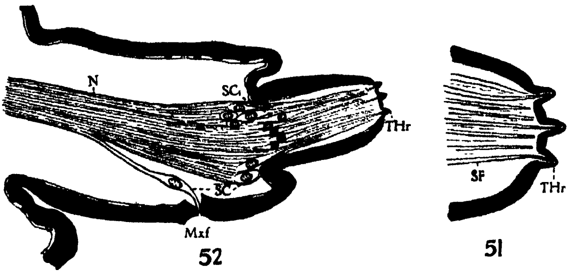
Nagel (1894) called the small hairs at the tip of the antennæ (Fig. 1, *THr*) of a lepidopterous larva olfactory pegs, but in the opinion of the present writer they are nothing more than tactile hairs. Sections through them show that they are not true hairs, because they do not arise from sockets, but each one is nevertheless innervated; the larger ones seem to be provided with sense cell groups (Fig. 49, *SCG*), while the smaller ones (Fig. 50, *THr*) arising from the dome seem to be provided with



FIGS. 49 AND 50.—Longitudinal sections, showing internal anatomy of antenna of tomato worm. Fig. 49, the larger type of one of Nagel's so-called olfactory pegs at tip of antenna, × 500; sense-cell group (*SCG*). Fig. 50 shows how well antenna is innervated; semidiagrammatic, × 100. Hypodermis (*Hyp*); nerve (*N*); antennal pore (*Anta*); probably hair-mother cell (*HrMC*); sense cell (*SC*), connected with pore; sense cell (SC_1), connected with peg; smaller type of one of Nagel's so-called olfactory pegs (*THr*) arising from dome; and base of large true hair (*Hr*).

single sense cells (SC_1). The large hair (*Hr*) at the tip of the antenna is a true hair, but it does not appear to be sensory, although lying at its base there are one or two large cells (*HrMC*) which resemble hair-mother cells more than sense cells.

One author draws the antennæ of lepidopterous larvæ as if they were composed of 3 or 4 segments, but sections show only two distinct segments in each, although sometimes the basal one is so folded that indications of two more segments are visible, as shown in Figure 50, which also gives a good idea of how well the antenna is innervated.



FIGS. 51 AND 52.—Longitudinal sections, showing internal anatomy of maxillary palpus. Fig. 51 shows sensory fibers (*SF*) running to 3 of hairs (*THr*) at tip of palpus of *Ceratomia catalpæ*, × 500. Fig. 52 shows how well palpus is innervated; semidiagrammatic, × 190. Sense cells (SC_1), connected with hairs (*THr*); sense cells (*SC*), connected with pores; maxillary pore *f* (*Mxf*); and nerve (*N*).

The terminal segment of the maxillary palpus ends bluntly (Fig. 53) and the tip is provided with 8 or 9 minute pseudohairs (Figs. 51 and 52, *THr*), each of which seems to be innervated by a single sense cell (SC_1). These sense cells lie in a group at the proximal end of the segment near another group of sense cells (*SC*) which evidently belong to the pores. Figures 52 and 53 show how well the maxillary palpus is innervated; a portion of the terminal segment in Figure 53 is shown in perspective.

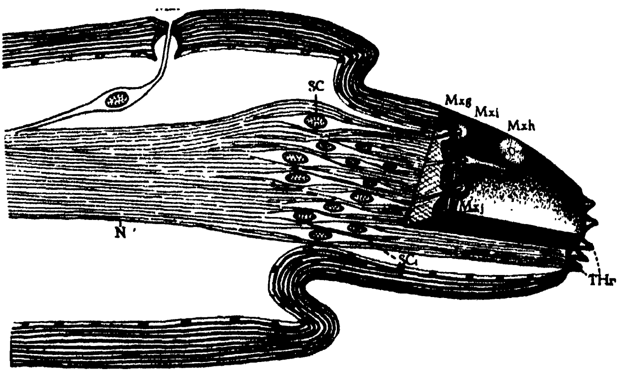


FIG. 53.—Schematic drawing of maxillary palpus of tomato worm, showing innervation of maxillary pores *f* to *j* (*Mxf* to *j*) and tactile hairs (*THr*); a portion of terminal segment is in perspective.

SUMMARY.

To determine whether lepidopterous larvæ respond to chemical stimuli, tent caterpillars, fall webworms, tussock-moth larvæ, army worms and larvæ of *Papilio polyxenes* were tested by using the following sources of odors: Oils of peppermint, thyme and wintergreen, dried leaves of pennyroyal and spearmint, wild cherry-tree leaves, fresh grass, old honey and comb, and the protruded thoracic glands of the above Papilio larvæ. The larvæ usually responded to the exhalations from these substances, but the average reaction times obtained seemed to depend more on the degree of sluggishness of the larvæ than on their sensitiveness to odors.

Organs, called olfactory pores by the writer, but known as punctures to systematists, were found widely distributed on the head capsule, head appendages, legs, dorsal surfaces of the prothorax and last abdominal segment, and on the anal prolegs. It is believed that a few of those on the head and all of those found on the legs and abdomen are here reported for the first time. Their internal structure is like that of those in adult insects and coleopterous larvæ, and consequently are well adapted to receive chemical stimuli, because their sensory fibers running from the sense cells pass into the minute pores or punctures and seem to come in direct contact with the external air. No experiments, however, were performed to determine their function.

Verschaffelt determined experimentally that cabbage-butterfly larvæ are attracted by the various mustard oils contained in the host plants, and this explains why these larvæ refuse plants not containing such oils; he also thinks that the larvæ smell the odors from the mustard oils before they begin to eat the food. If we knew more about the chemotaxis of insects, we might be able to devise practical methods for the control of certain insects, as by trap baits, etc.

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THE STREPTOCERA GROUP OF THE DIPTEROUS GENUS TIPULA LINNAEUS.

W. G. Dietz, M. D.

A natural group of species, which briefly may be characterized as follows: Wings approximately unicolorous, stigma distinct, the antestigmal spot always extends into cell 1st M2, but is interrupted in the outer end of cell R in most of the species. The eighth sternite of the male is prolonged and narrowed posteriorly, except devia. The hypopygium is of moderate size. The ninth tergite, generally small, is emarginate in the middle, except fragmentata. The pleural suture is distinct, except devia—the pleurite prolonged into a process, generally long and twisted, hornlike, rarely into an acutely pointed cone, derbyi, or simply tipped by a sharp point, devia. The ovipositor is very short, the upper valves generally rounded or oval, in some species ending in a downward curved point, giving thus a beaklike appearance; the lower valves scaphoidal. In all the specimens in my collection, the posterior end of the abdomen, especially the males, is curved upward and sometimes backwards towards the abdominal tergum. Whether this also obtains in the living insect I have no means to know.

The species, below medium in size, are yellowish to testaceous in color, with more or less lustre. They resemble each other very closely and the genital structure of the males must in almost all cases be depended upon for differentiation.

KEY TO THE SPECIES.

1. Joints of the antennal flagellum unicolorous. Western species 2
   Flagellar joints bicolored. Eastern United States; aberrant form. .... *devia* spec. n.
2. The ninth tergite of the male distinctly emarginate 3
   Not as in the alternative .... *fragmentata* spec. n.
3. The pleural process long, hornlike 4
   The pleurite prolonged into a pointed, conelike process .... *derbyi* Doane
4. The pleural process long, twisted, more or less curved, glabrous 5
   The process shorter, approximately straight, stiletto-like, hairy, ... *monochroma* Spencer
5. Process conspicuously curved 6
   Process approximately straight .... *trypetophora* spec. n.
6. The ninth tergite with a deep, oval emargination, the sides prolonged into converging processes, the inner margin with a conspicuous tooth. .... *opisthocera* spec. n
   Not as above 7
7. Process shorter, viewed laterally, much wider in basal half... *mutica* spec. n.
   Not as in the alternative 8
8. Antennal flagellum—except basal joint—dark brown .... *streptocera* Doane
   Antennæ entirely yellowish .... var. *streptocera pallidocera* var. n.

Tipula devia sp. nov.

Yellow. Antennæ yellow, flagellar joints beyond the third, brown at the base. Thoracic stripes obsolete. Pleurite of hypopygium tipped with a sharp point.

Male, length 13 millimeters, wing 14.5 millimeters.

Head entirely, together with mouth-parts and palpi, yellow; last joint of palpi a trifle longer than the three preceding joints together. Antennæ yellow, flagellar joints beyond the third brownish at the base; joints cylindrical, basal enlargement very slight, the setæ about as long as the respective joints. Thorax concolorous, dorsum subtranslucent, stripes obsolete, pleura with a faint whitish sheen, coxæ and trochanters yellow, rest of legs lost. Halteres pale yellow, club infuscate. Wings light gray, costal cells yellow, stigma light fuscous, veins C, S C, R and Cu, yellow, the other veins brown; the antestigmal spot strongly marked, extending through cell 1st M2 into base of cell M3. As far as I can perceive, vein M1 and M2 alone are distinctly setigerous, the setæ rather long.

Abdomen yellow, darker posteriorly, the eighth sternite very little prolonged, the posterior margin with a median notch and a slight emargination on each side; a dense brush of golden-yellow, bristly hair arises from beneath the margin and a stout bristle, curved outward from the lateral angle. Hypopygium (Pl. V, Figs. 1 and 2) testaceous. Ninth tergite markedly narrowed posteriorly, deeply emarginate, the upper surface impressed mesially, the sides of the tergite prolonged into an acute process, denticulate within. Ninth sternite broadly emarginate, base of the emargination subangulate. Pleural suture obsolete, the pleurite projects as an acute point. Outer apical appendages large, hatchet-shaped, projecting inward, lower appendages large, sausage-shaped bodies, coarsely hairy and projecting downward into the emargination of the ninth sternite.

Holotype, ♂. Plummers Island, Maryland, June 28th, 1914 (W. F. McAtee).

A distinct, but somewhat aberrant species in this group. The absence of the pleural suture, the pleurite merely projecting into an acute point and the scarcely prolonged eighth sternite is at variance with the other species included in this paper. It is the only species with bicolored antennal flagellum and the only one from the Eastern United States. The type and only specimen is defective, an antenna, one wing and all the legs wanting.

NOTE:—Since the above has been written, three more specimens of this species have turned up in my collection. A male, Southern Pines, North Carolina, June, 1910, (A. H. Mance); a male and female specimen, Black Mountain, North Carolina, July, 1912, (Wm. Bentermueller).

Allotype, ♀, has the ovipositor elongated, testaceous and highly polished. The upper valves long and slender, pointed. The lower valves nearly four-fifths the length of the upper valves, obtuse at the apex.

Tipula fragmentata sp. n.

Reddish-brown with some lustre. Thoracic stripes distinct; ninth tergite rounded posteriorly, with a subtriangular prolongation from beneath the posterior margin. Pleural prolongation slender, twisted, strongly inclined proximad.

Male, length 11 millimeters, wing 13.5 millimeters.

Head dark, margin of orbits whitish. Frontal prolongation rather long, reddish-brown, shining, beset with black hairs. Nasus short, obtuse, with a tuft of white hair at the apex. Palpi brown. Scape and first flagellar joint of the antennæ pale yellow, second flagellar joint fuscous, remainder of antennæ wanting.

Thoracic stripes reddish-brown, with some lustre, separated by five yellowish lines of the ground color; the median stripe divided by a fine line. Pleura fuscous, dull. Scutum uniformly dark fuscous with a faint lustre. Scutel yellowish and like the yellowish-fuscous postnotum, shining. Legs slender, yellowish, femora yellow, apices fuscous; tibiæ and tarsi yellowish-fuscous. Halters yellowish, knob wanting. Wings grayish, stigma fuscous, the antestigmal spot faint interrupted in cell 1st, M2; a hyaline spot beyond the stigma.

Abdomen pale testaceous, shining, with median dorsal and lateral stripes, the latter somewhat interrupted; the median stripe does not extend upon the posterior tergites. Hypopygium (Plate XXX, Figs. 3 and 4) yellowish, pleural processes brownish. Ninth tergite rounded posteriorly and from beneath its posterior margin extends a subtriangular process or prolongation. Ninth sternite deeply emarginate, the emarginations almost entirely canceled by the narrowed end of the prolonged eighth sternite, the latter with a brush of hair at its apex. Pleural processes twisted, broad at the base, strongly attenuated and twisted outwardly, inclined towards each other. The outer apical appendage digitiform, extends obliquely inward.

Holotype, ♂, bears a label marked California (Bradley), Type C. U.

The specimen is in the collection of Mr. C. P. Alexander. It was received in alcohol and practically dismembered. In its hypopyginal characters, however, more especially the rounded ninth tergite, it is at once differentiated from all the other species. In its distinct thoracic stripes it resembles *streptocera*,* *trypetophora* and *opisthocera*.

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* A specimen, labeled *T. streptocera*, received from Prof. Doane, and another from my collection, determined by him, have the thoracic stripes nearly obsolete. The same is also the case in nearly all the specimens of this species in my collection.

Tipula monochroma spec. n.

Yellowish. Antennal flagellum unicolorous, fuscous. Thoracic dorsum brownish-yellow, dull. Prolongation of pleurite straight, stilletto-like, hairy.

Male. Length 11 millimeters; wing 12.5 millimeters.

Head concolorous; front and occiput gray, with a fine, dark median line. Frontal prolongation long, shining and like the nasus above, beset with short, blackish hairs. Palpi sordid yellow, last joint infuscate and scarcely longer than the preceding joints together. Antennæ moderate, the three basal joints yellowish, the remainder fuscous; segments sub-cylindrical, the basal enlargement blackish, each with a whorl of black, moderately long setæ.

Thoracic dorsum brownish-yellow; pronotal scutem darker about the middle. Praescutal stripes ill-defined by fine, paler lines. Scutum, scutellum and postnotum semiopaque, slightly more infuscate and somewhat sericeous. Pleura pale yellowish, sericeous. Legs yellowish, outer tarsal joints infuscate, the whole leg beset with coarse, short black hairs. Halters pale, club infuscate. Wings pale grayish; costal cells very pale yellowish; stigma pale, slightly infuscate. The antestigmal spot inconspicuous, extends through cell 1st M2 to base of cell M3, and sending a narrow, pale streak to the wing margin. The veins included in the antestigmal spot are whitish. Veins R and Sc. yellow, the other veins dark brown and delicate. The veins beyond the cord are indistinctly margined with subhyaline. The R, s, and the veins beyond the cord, except those limiting cell 1st M2, setulose.

Abdomen darker yellow, almost testaceous, shining; an ill-defined, more or less interrupted, fuscous dorsal stripe; tergites three to seven with a fuscous spot near the anterior angle and from which extends an indistinct streak along the lateral margin of the tergite. Venter with median blackish stripe, somewhat interrupted and obsolete beyond the fourth sternite. The eighth sternite projecting, narrowed posteriorly, the apical margin nearly truncate, with a brush of stiff, yellowish-fuscous, incurved bristles. Hypopygium (Pl. V, Figs. 7 and 8) dark testaceous, medium sized. The ninth tergite broad, slightly narrowed posteriorly, the free margin with small V-shaped, median notch, emarginate each side, the apical angles curved downwards. Ninth sternite with a rather deep, V-shaped emargination, from which projects a pencil of stiff bristles, lateral angles with a small appendage, beset with bristles. Pleural suture distinct. The pleural process has the shape of a stilletto, beset with hairs. The outer appendages are yellowish-white, membranous, bilaminate, somewhat protuberant and acuminate; the inner lamina beset with bristles, directed inwardly.

Holotype, ♂, Chimney Gulch, Golden, Colorado, (E. J. Oslar).

Paratype, ♂, Silver City, Nevada, June 3rd, 1913.

The paratype is paler than the holotype; the dark markings of the abdomen, with the exception of the lateral spots, nearly obsolete. The hairy stiletto-shaped pleural process of the male will readily distinguish this species.

Tipula trypetophora spec. n.

Yellowish, testaceous, shining. Antennal flagellum unicolorous. Thoracic stripes distinct. Wings faintly gray, veins beyond the cord broadly margined with hyaline. Pleural process conspicuous, long, twisted, nearly straight.

Male. Length, 13.5 millimeters; wings, 13.5 millimeters.

Head testaceous. Frontal prolongation and rostrum beset with short, black hairs. Palpi fuscous, the last joint scarcely as long as the preceding joints together. Front and occiput fuscous with an obscure, median darker line; the space surrounding the antennal insertion somewhat paler. Antennæ of moderate length; scapal joints pale yellow, first flagellar joint pale yellow at base, infuscate apically, the remaining joints fuscous, cylindrical, basal enlargement with the usual whorl of setæ, the latter shorter than the respective segments; pubescense whitish, very short; the last antennal joints rather strongly attenuate.

Thorax concolorous, shining. Pronotum scarcely darker in the middle. Praescutal stripes brown, well defined, the median stripe very little narrowed posteriorly, the lateral stripes abbreviated in front, extended upon the scutum, leaving a narrow external and internal margin of the ground color. Scutel and postnotum concolorous. Pleura with a pale sheen. Legs yellow, femora somewhat infuscate at the apex; tibiæ darker yellow; tarsi fuscous; tibiæ and metatarsi subequal; pilosity very dense, short, blackish. Halters sordid yellow, club infuscate. Wings grayish-hyaline, costal cells with a faint, yellowish tinge, stigma pale yellowish-fuscous. Veins brown, those beyond the cord broadly margined with hyaline. Cell 1st M2 fully two and one half longer than wide. The antestigmal spot more or less interrupted, extends into cell 1st M2, Rs. and veins beyond the cord, except Cu_1, setulose.

Abdomen concolorous; an ill-defined dorsal stripe, more distinct posteriorly; sides of tergites three to eight somewhat infuscate, three to five with a dark fuscous spot near the anterior angle. Venter with ill-defined, median darker stripe. The eighth sternite strongly narrowed and prolonged posteriorly, the apical angles with a small, triangular appendage; two narrow processes project from the middle of the posterior margin, the latter without a brush of hair. Hypopygium (Pl. V, Figs. 9 and 10) reddish-testaceous and rather large. The ninth tergite short, with narrow median incision, the apex of each side curved dorsad in the form of a small, obtuse tubercle, which is concave and shining on its posterior face. Ninth sternite short, broadly emarginate; pleural suture complete. Pleural process conspicuous, twisted at the base and within the latter arises a sharp, conical process; the direction of the process is nearly straight, caudad; apical appendages inconspicuous.

Female. Length 12.5 millimeters; wing, 13.5 millimeters. Flagellar joints two and three yellowish towards the apex, remainder of flagellum light brown. The lateral abdominal stripe distinct from tergite three to eight. Ovipositor short, concolorous, viewed laterally upper valves almost circular, lower valves elliptic, the upper margin ending in a very fine, spine-like prolongation.

Holotype, ♂, Victoria, British Columbia, July 6th, 1912.
Allotype, ♀, topotypic.
Paratypes, 1 ♂, 6 ♀ ♀'s, topotypic.

This species very closely resembles opisthocera. The wings are a trifle paler, likewise the stigma. The very different construction of the ninth tergite of the male, absolutely differentiates the two species. One male paratype has the thoracic stripes much less distinct.

Tipula opisthocera spec. n.

Testaceous; antennal flagellum unicolorous, fuscous. Thoracic stripes distinct. Pleural process conspicuous, strongly curved.

Male. Length, 12 millimeters; wing, 15 millimeters.

Head concolorous; frontal prolongation long, clothed with blackish hair, rather long on the nasus. Palpi brownish, the fourth joint darker and but little longer than the three preceding joints together. Face yellow. Antennæ slender, scapal joints yellow, first flagellar joint yellowish fuscous, joints subcylindrical, basal enlargement moderate with a whorl of rather long, black bristles; pubescense very fine, short, whitish. Front and occiput very dark fuscous, except near the base.

Thorax concolorous, shining. Praescutal stripes distinct, brown, rather broad and indistinctly margined with darker brown, the median stripe scarcely narrowed posteriorly, the lateral stripes much abbreviated in front, continued upon the scutum, where they leave but a narrow lateral stripe and a very narrow margin within, of the ground·color. Scutellum and postnotum concolorous, lightly touched with fuscous. Pleura pale testaceous, with a faint, pale sheen. Legs yellowish-brown, densely clothed with brown hair; coxæ and base of femora paler, yellow; apices of femora and tibiæ fuscous, the latter longer than the metatarsi; tarsi fuscous. Halters concolorous, paler at base, club infuscate. Wings grayish with a fuscous tinge; vein M and all the veins beyond the cord broadly margined with hyaline; costal cells a very faint yellow; stigma brown; the antestigmal spot extends into the base of cell M3, is faint beyond cell R1; a hyaline spot beyond the stigma. Rs, vein M and the apical veins except those limiting cell 1st M2, strongly setigerous.

Abdomen testaceous, paler towards the base; a fuscous dorsal stripe extends from the second tergite to the end of the seventh, becoming more diffused posteriorly; tergum indistinctly margined with fuscous, more accentuated in a dark spot on the anterior angles of tergites three to seven, a faint median ventral stripe. The eighth sternite clasping cephalad, narrowed and somewhat prolonged posteriorly, the caudal margin rather deeply emarginate, with a triangular appendage at each angle of the emargination, the latter filled with a whitish membrane, which has the appearance as though it consisted of matted hair. Hypopygium (Pl. V, Figs. 11 and 12) reddish-brown; ninth tergite rather narrow, directed obliquely dorsad, somewhat turgid, with a very deep oval emargination, the lateral angles prolonged, turgid,

inclined inwardly, the inner margin with a large obtuse tooth and several smaller denticles. Ninth sternite very short, with slight medium notch. Pleural process long, somewhat flattened, twisted and appearing like an extended S. Apical appendages small and inconspicuous.

Female. Length, 12 millimeters; wing, 13.5 millimeters.

Antennæ shorter and more slender. Dorsal stripe of abdomen broader and more diffused posteriorly; the lateral stripes broad, strongly marked, tergites three to seven without lateral spots. Eighth segment entirely fuscous. Ovipositor dark testaceous, the upper valves short, quadrate-oval, dark brown; lower valves paler, very small, scaphoidal.

Holotype, ♂, Sonoma County, California, April 20th, 1914.

Allotype, ♀, topotypic.

Paratypes, 4 ♂♂'s, 3 ♀♀'s, topotypic.

A very distinct species. The ninth tergite of the male, with its deep, oval emargination, the sides thereof prolonged and strongly incurved with a large, obtuse point on its inner margin, distinguish this from the other species. The thoracic stripes are pronounced in all my specimens.

Tipula mutica spec. n.

Yellowish testaceous, shining. Antennal flagellum unicolorous. Thoracic stripes almost effaced. Pleural process twisted, curved, broad in basal portion.

Male. Length 12 millimeters; wing, 14 millimeters.

Head. Frontal prolongation and rostrum reddish-brown, with short, black hair. Palpi dark fuscous, joints two to four whitish at the base, the fourth joint scarcely as long as the preceding joints combined. Front and occiput grayish-fuscous, whitish along the upper orbital margin, a dark brown fronto-occipital stripe. Antennæ of moderate length, slender; first three joints pale yellow, remaining joints fuscous; basal enlargement of segments blackish with the usual whorl of setæ, the latter much shorter than the respective segments; pubescense fine, whitish.

Thorax concolorous, shining, the stripes faintly indicated, a shade darker than the ground color. Scutel and postnotum finely sericeous. Pleuræ pale yellow, faintly sericeous. Legs yellow, femora and tibiæ infuscate at the apex; the short, dense, black pilosity gives the legs a darker appearance; tibiæ distinctly longer than the metatarsi; tarsi fuscous. Halters pale fuscous, lighter towards the base, club dark fuscous. Wings pale gray, costal cells with a pale, yellow tinge, stigma pale yellowish-brown. Cell 1st M2 about twice as long as wide, veins brown, those beyond the cord broadly margined sub-hyaline, veins M and Cu less distinctly margined. The antestigmal spot is rather faint and does not extend beyond cell 1st M2; a faint hyaline spot beyond the stigma. R s, veins M, Cu, A_1 and apical veins setulose.

Abdomen testaceous, shining; a well marked dorsal stripe extends from the first to the eighth tergite, a lateral fuscous stripe more or less interrupted, extends from the third to the sixth tergite, more accentuated in a darker spot near the anterior angle of the respective segments. Eighth sternite prolonged and narrowed posteriorly, the posterior margin with a broad, rounded emargination which is filled with a whitish membrane; each angle of the emargination bears a large, triangular appendage, the inner margin of which has a brush of short, dense, golden-yellow hair. Hypopygium (Pl. V, Figs. 13 and 14) reddish, testaceous. The ninth tergite about as long as wide, broadly and deeply emarginate, the lateral angles prolonged as digitiform processes, slightly bent downward at the apex; the upper surface of the tergite with a median, longitudinal carina; viewed laterally, the upper surface appears subangulate about the middle. Ninth sternite short, with a median acute incision. Pleural suture complete, pleural process conspicuous, curved upward and markedly broadened just beyond the base, convoluted, then extending directly caudad and slightly bent outwardly. The outer apical appendages small, ovoidal, fringed with hair; the inner appendages a broad perpendicular lamina, extending above into an acutely pointed and strongly chitinized process; the lower margin strongly bearded with yellow, bristly hair.

Holotype, ♂, Somona County, California, May 21, 1914.

Paratypes, 4 ♀ ♀'s, topotypic.

The formation of the hypopygium alone must be depended on for differentiation from allied species.

Tipula streptocera-pallidocera var. n.

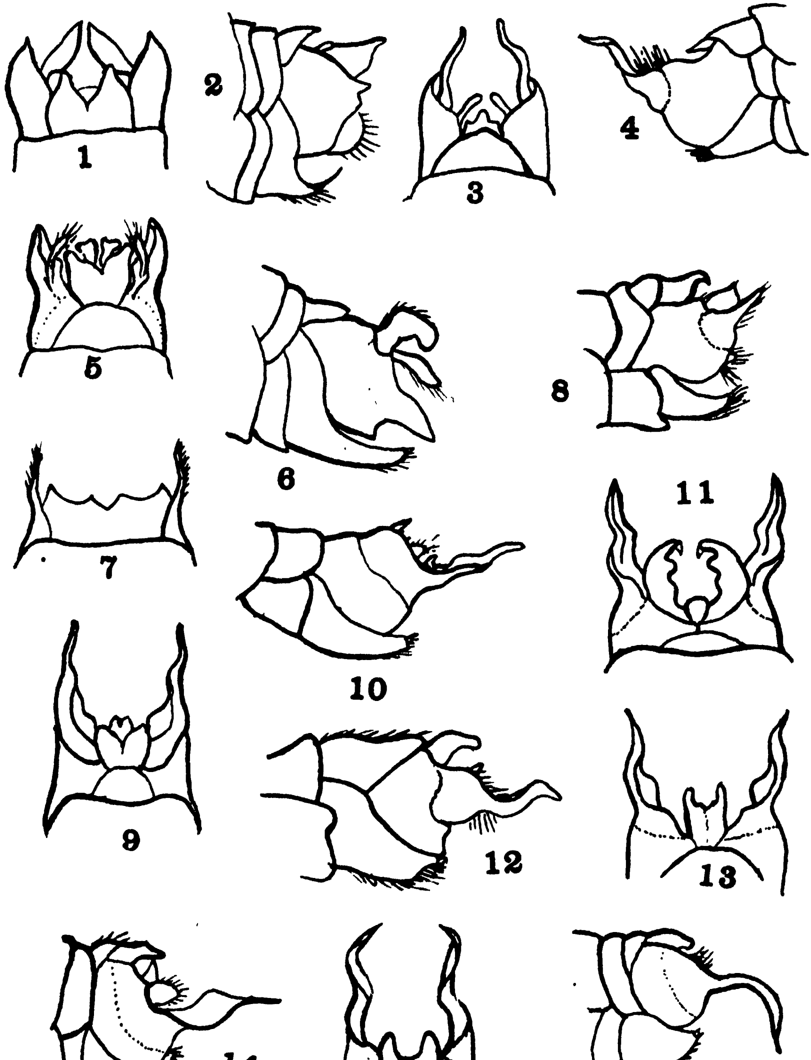
A specimen in my collection received from Prof. Doane and bearing the label "*L. streptocera,*" agrees in all details with the description and other specimens of this species, received or determined by its author, except that the antennæ are entirely pale yellowish. The thoracic stripes are ill defined.

Holotype, ♂, Keyport, Washington, July, 1905, (R. W. Doane).

EXPLANATION OF PLATE V.

Hypopygia.

Fig. 1. Dorsal aspect of *T. devia.*
Fig. 2. Lateral aspect of *T. devia.*
Fig. 3. Dorsal aspect of *T. fragmentata.*
Fig. 4. Lateral aspect of *T. fragmentata.*
Fig. 5. Dorsal aspect of *T. derbyi.*
Fig. 6. Lateral aspect of *T. derbyi.*
Fig. 7. Dorsal aspect of *T. monochroma*, without apical appendages.
Fig. 8. Lateral aspect of *T. monochroma.*
Fig. 9. Dorsal aspect of *T. trypetophora.*
Fig. 10. Lateral aspect of *T. trypetophora.*
Fig. 11. Dorsal aspect of *T. opisthocera.*
Fig. 12. Lateral aspect of *T. opisthocera.*
Fig. 13. Dorsal aspect of *T. mutica*, without apical appendages.
Fig. 14. Lateral aspect of *T. mutica.*
Fig. 15. Dorsal aspect of *T. streptocera*, without apical appendages.
Fig. 16. Lateral aspect of *T. streptocera.*



W. G. Dietz

LIFE HISTORY AND BIOLOGICAL NOTES ON CHLAENIUS IMPUNCTIFRONS SAY. (COLEOPTERA, CARABIDÆ).*

P. W. CLAASSEN.

In the Proceedings of the Entomological Society of Washington I, 22, 1884, C. V. Riley says: "Perhaps one of the most interesting discoveries of the year 1884 is the mode of oviposition in some of our Carabidæ. From the terrestrial habits of most of our species one would expect that the eggs are deposited within the ground, and such may yet prove to be the case with many; but I have proved by actual breeding from eggs to the imago that it is not so with *Chlænius impunctifrons*, and have strong proof that *Chlænius æstivus*, *Scarites subterraneus* and the genera *Dicælus* and *Galerita* share with that species its singular mode of oviposition. The remarkable and unexpected fact, in insects so essentially terrestrial, is that the eggs are laid singly on the leaves of trees and shrubs and encased in a covering of mud or clay. I had often observed these little convex mud cells on the under side of leaves while collecting along the Mississippi in Missouri in years gone by, and was puzzled to make out their real nature. In May and June, 1883, while collecting on the Virginia side of the Potomac, I found these clay cells tolerably common and, fortunately, fresh, each containing a large soft white egg. That year I obtained larvæ, but only during the past year were any of these reared to the imago."

The above account is not accompanied by any figures or descriptions, and as far as I am aware, the life history of *Chlænius impunctifrons* has not been written hitherto.

On May 23, 1918, while collecting in the cat-tail marshes around Ithaca, New York, I observed a little ball of mud on the upper surface of a leaf of Typha. The mud ball occurred near the tip of the leaf, four to five feet above the surface of the ground. I took the leaf with the mud ball into the laboratory and upon breaking it open found a glistening white egg inside. Plate VI, Fig. 5. The egg was put into a tin salve box for rearing. The following day I found two more of the same kind of mud

* Contribution from the Department of Entomology, Cornell University.

cells, each on a Typha leaf near the tip. These two specimens also were brought to the laboratory and placed in the tin box with the other egg.

On May 28th the first egg had hatched. The young larva had opened one of the other mud balls and devoured the egg within. The third mud ball was then removed to another tin box. The first young larva died two days later, May 30th. That left only one egg of the lot. This egg hatched on the first of June, six days after it had been brought into the laboratory. The young larva was transferred to another clean tin salve box containing moist, sterilized sand.

Various kinds of food were offered to the young larva; larvæ and pupæ of *Lymnæcia phragmitella* Stainton, larvæ of *Nonagria oblonga* Grote, *Arsilonche albovenosa* Goeze, and *Arzama obliqua* Walk. Flies and fresh meat were also offered to the larva. At first the young larva fed somewhat on flies and on larvæ and pupæ of *L. phragmitella*, but it showed a decided preference for the little larvæ of *A. obliqua*.

During the second and third instar all other food was refused except larvæ of *A. obliqua*.

All the above mentioned Lepidoptera are inhabitants of Typha. *A. albovenosa* is an incidental surface feeder on the leaves; *L. phragmitella* lives in the heads of Typha, while *A. obliqua* and *N. oblonga* both begin their larval activities as leaf miners, later becoming solitary stem borers.

It is possible that the larvæ of *Chlænius impunctifrons* feed altogether on the larvæ of *A. obliqua*. The former hatch about the same time that the larvæ of the latter species leave the mines of the leaves of Typha to become stem borers. Thus while they are exposed they might easily fall prey to the Carabid larvæ.

On June 3, 11:00 A. M., the larva cast its first skin, the first instar having lasted three days. June 6, at noon, the larva molted again. The third instar larva had a voracious appetite and consumed many of the little *A. obliqua* larvæ. Five days later, June 11, the larva had tunneled into the moist sand and hollowed out a little cell. In this cell it was lying on its side as if ready to pupate. Having been disturbed the larva came to the surface of the sand and remained there, lying on its back. Whenever the box was opened it made efforts to turn over but was unable to do so. When turned over the larva crawled

about a little but soon fell over on its back again. In this condition the larva remained on top of the sand for sixteen days without taking any food. On June 27th the larva pupated. The pupa remained quietly on its back till July 4th, when the adult emerged. The adult was rather weak. The legs, especially the metathoracic legs, were not fully developed. The adult specimen was determined by Dr. J. C. Bradley.

TABLE OF INSTARS.

		LENGTH OF STAGE
Egg found	May 24	
Egg hatched	June 1	Egg stage 7 days plus?
First molt	June 3	First instar 3 days.
Second molt	June 6	Second instar 3 days.
Pupation	June 27	Third instar 21 days.
Emergence of adult	July 4	Pupal period 7 days.

DESCRIPTION OF STAGES.

MUD CELL.

(Plate VI, Fig. 5).

The little mud ball which encloses the egg is made of fine gray sand. It is placed singly on the upper surface of a Typha leaf six to eight inches from the tip. The mud ball is oblong oval, somewhat depressed. It measures 3.43 mm. in length, 2.28 mm. in width, and 1.75 mm. in thickness.

EGG.

(Plate VI, Fig. 1).

In the center of the mud cell occurs the egg. It is oblong oval, of a glistening white color, with rather large faint reticulations. It measures 2.28 mm. in length and 1 mm. in its greatest diameter.

FIRST INSTAR LARVA.

(Plate VI, Fig. 3).

Color. General color of larva dark brownish black, except in the less chitinized places which are grayish white. Head yellowish brown with a dark brown area in front between the epicraneal sutures. Antennæ and maxillary palpi dark brown, with a narrow yellow-brown ring at the joints.

Form. The body is elongate, tapering to both ends, but more posteriorly. The ninth abdominal segment bears two processes which equal the combined length of the pro- and mesothorax. The anal tube projects posterio-ventrad from the ninth abdominal segment.

Head. Head, excluding mouthparts and appendages, wider than long, narrowed behind the eyes. Dorsal surface slightly convex, with two short oblique grooves terminating at the lateral margin. Ventral surface more convex. Edge of labrum roughly toothed, with one larger tooth on each outer angle of the anterior margin. Surface of head smooth

with few hairs. Ocelli six, on a raised portion back of the antennæ. Antennæ four-jointed, the first and fourth joint about equally long; the second joint two-thirds the length of the first; the third joint slightly longer than first, with a crook above the middle. Two or three bristles originate from this outward crook or elbow, and one from the inner side. Fourth, or apical joint, with four bristles at the tip.

Mandibles long curved, with a strong tooth below the middle, directed inward and slightly downward. A small bunch of hairs near the inner base of mandibles.

Maxillæ with a long stout basal joint, bearing numerous hairs, especially on the inner and upper surface. Outer palpus four-jointed; first joint as wide as long, second joint somewhat more slender and at least twice as long; third joint slender and a little shorter than second; fourth joint as long as first, but very slender. Inner palpus two-jointed, the basal joint stouter and a little longer than second. Just inside the inner palpus is another small joint tipped with a bristle.

Mentum about as wide as long. Anterior margin produced to a point bearing two hairs. Palpus with basal joint little longer than broad; second joint little longer than first and tapering greatly.

Prothorax narrowing anteriorly, a third wider than long. Surface finely punctate.

Meso- and Metathorax each twice as wide as long.

Abdomen of nine true segments, gradually tapering posteriorly. The ninth segment bears the anal tube and the two posterior processes. These processes each bear five long stout hairs, three about equidistant along the process and two at the tip.

Legs long with stout hairs and two claws at the tip.

Measurements of Cast Skin. Length from tip of mandibles to tip of caudal processes, 7.43 mm.; greatest width across thorax, 1.26 mm.

SECOND AND THIRD INSTARS.

The second and third instar larvæ do not differ greatly in structure from the first except in size and proportions. The first instar is more spindle shaped. The body of the second and third instar is more flattened.

SECOND INSTAR LARVA.

(Plate VI, Fig. 7).

The second instar larva differs from the first in the following points.

Antennæ. First and third joint of equal length. Second and fourth joint subequal, each a little shorter than first and third joint.

Palpi of mentum with basal joint twice as long as broad; second joint as long as first.

Prothorax about twice as wide as long.

Meso- and Metathorax each more than twice as wide as long.

Caudal processes with four long hairs; one about half way back, another three-quarters back, and two at the tip.

Measurements of Cast Skin. Length from tip of mandibles to tip of caudal processes, 10.28 mm.; greatest width across thorax, 2.25 mm.

THIRD INSTAR LARVA.

(Plate VI, Fig. 4).

Antennæ. First, second and third joints of equal lengths. Fourth joint about two-thirds the length of the other segments.

Prothorax less than twice as wide as long, i. e., the width equals one and three-quarters the length.

Caudal processes as in the second instar.

Measurements of Cast Skin. Length from tip of mandibles to tip of caudal processes, 14.57 mm.; greatest width across throax, 3.43 mm.

PUPA.

(Plate VI, Fig. 2).

The pupa is of a creamy white color. The eyes are the first to show a mottled brown color. The mandibles also become chitinized early.

Ventral view. Head bent under so as to show a small portion of the prothorax. Labrum and clypeus together a third longer than broad, emarginate in front. Mandibles long with a notch and tooth at the apex. Maxillary and labial palpi plainly visible. Front of head with four setæ arranged as shown in figure. Antennæ eleven jointed, the tips almost reaching the tips of the metathoracic wings. Prothoracic legs extending to a point half way between the tips of the maxillary palpi and the tips of the antennæ. Mesothoracic legs underneath the antennæ, extending slightly beyond the tips of the antennæ. Metathoracic legs visible only at the tips where they project from beneath the metathoracic wings. Elytra show the longitudinal striæ plainly. The elytra extend about two-thirds the length of the metathoracic wings. Wings with a hump on the lateral margin. They extend back to a point one-third across the fourth abdominal segment. Abdomen with segments two to nine visible. Segment two with a small hair-tipped tubercle on each lateral margin. Segments three, four and five each with lateral processes as shown in the figure. Segments seven and eight smooth. Segment nine with two short posterior tubercles.

Dorsal view. Dorsally the pupa presents a hairy appearance. Long hairs occur on all but the last three abdominal segments. On the thorax the hairs are shorter and occur more scatteringly. On segments one to six, of the abdomen, the hairs are long and are arranged in two groups on each segment; one group on each side of the median line. The hairs are arranged in two more or less distinct rows, thirteen hairs in each lateral group, or twenty-six long hairs on each segment.

Measurements of the living pupa. Length, 10.28 mm.; greatest width of abdomen not including the lateral processes, 4.57 mm.

ADULT.

(Plate VI, Fig. 6).

The adult which emerged from the pupa in the laboratory measured 13.7 mm. in length and 4.7 mm. in its greatest width. The original description of the adult is found in the Transactions of the American Philosophic Society II, 64, 1823.

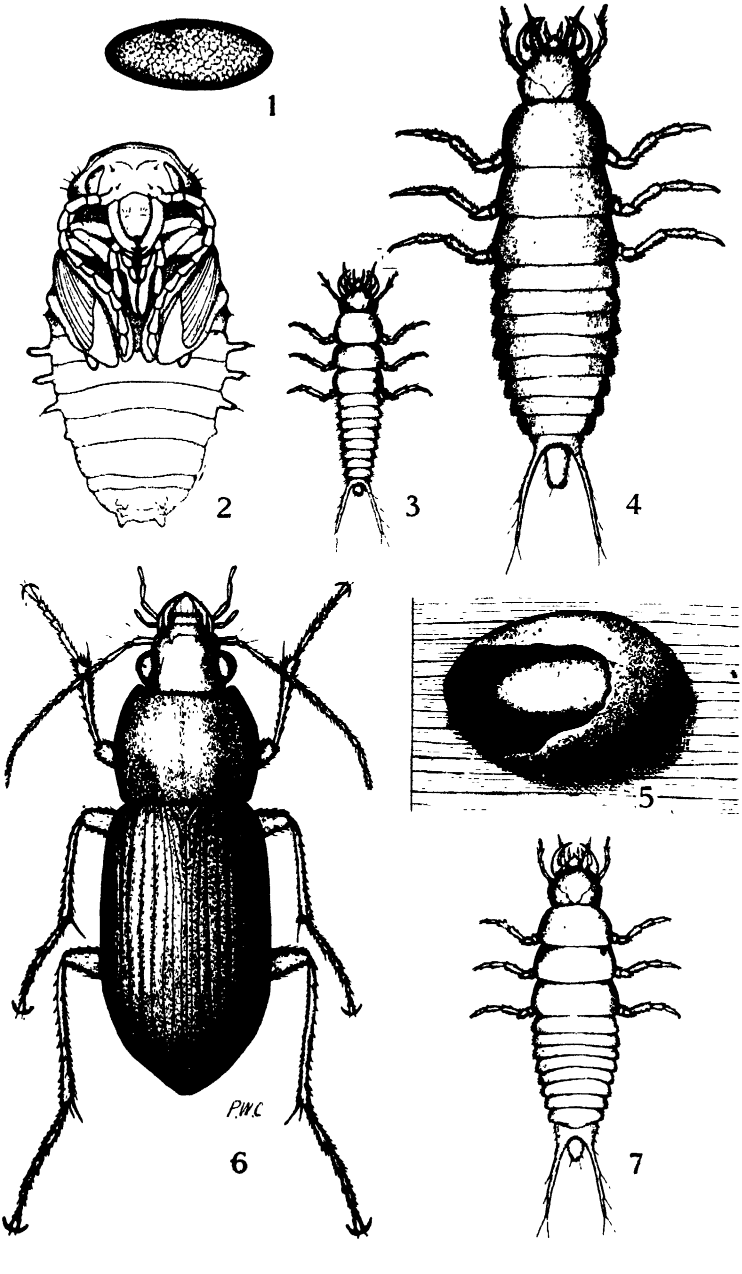
EXPLANATION OF PLATE VI.

Chlaenius impunctifrons Say.

Fig. 1. Egg, length 2.28 mm.
Fig. 2. Pupa, ventral view, length 10.28 mm.
Fig. 3. Larva, first instar, length 7.43 mm.
Fig. 4. Larva, third instar, length 14.57 mm.
Fig. 5. Mud cell on leaf. Opened to expose egg inside.
Fig. 6. Adult beetle, length 13.7 mm.
Fig. 7. Larva, second instar, length 10.28 mm.

Figures 2, 3, 4, 6 and 7 all drawn to the same scale.

P. W. Claassen, Del.



P. W. Claassen

ROBBERFLIES OF THE GENUS ERAX.*

JAS. S. HINE.

The species of this genus are flies of medium to large size. Their larvæ, so far as known, live in the soil and are predaceous, feeding on various forms of animal life present in such situations. The adults prey on many kinds of insect life, and with other genera of the same family may be considered as having the same relation among insects as hawks among birds.

Scopoli proposed *Erax* as a generic name in 1763 and included under it fourteen species. No genotype was proposed until 1910, when Coquillett designated one of Scopoli's species, *barbatus*, as the type. As matters stand at the present time all the species which Scopoli placed under *Erax* are located in other well established genera and the genus in his sense is left without a single representative.

In 1838 Macquart used *Erax* as a generic name. He gave Scopoli credit for the genus, but the characterization he used differs to such an extent that an entirely new group of species was admitted, and some of these have long been known as typical species of *Erax*. It is evident therefore, that opportunity for change of generic name is presented, but no action is taken because I am satisfied to use *Erax* in Macquart's sense and thus obviate the changes which another interpretation would involve. Since no genotype has been named for the genus in Macquart's sense, *Erax rufibarbis* Macquart is designated as the type of *Erax*. It is the twenty-second species in Macquart's arrangement in Dipt. Exot., I, 2, 107–119.

As an attempt has been made to associate and study all the North American species of the genus it was necessary to procure the loan of much material and to receive aid from various sources. A generous response has made it possible for me to do much more than could have been accomplished otherwise, and my appreciation is most cordially extended to the following institutions and students for services rendered:

Kansas University, Academy of Natural Sciences, National Museum, Carnegie Museum, Museum of Comparative Zoology, American Museum of Natural History, Biological Survey, Charles W. Johnson, J. M. Aldrich, Frederick Knab, Nathan

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*Contribution from the Department of Zoology and Entomology, Ohio State University. No. 57.

Banks, J. C. Bradley, Charles Schaeffer, R. H. Beamer, C. P. Alexander, F. R. Cole and A. L. Lovett. Much material has been procured also by purchase or exchange from others who have expressed interest in the work.

Having at my disposal an extensive collection of the species of *Erax* from a wide range of territory in North America, a careful attempt has been made to properly identify the species concerned. Types have been studied in all cases where such were available. In some instances descriptions had to be used entirely and since some of these descriptions, of older authors especially, are brief and indefinite it is not impossible that oversights have occurred. The external male genitalia are used much in designating species. The vestiture of these organs obstructs one's view at times, but the dorsal part is less obscured than the ventral, so the former has been outlined more carefully, and is the part to which students are referred as an aid to specific determination.

It has not been possible to reach a conclusion in regard to the identity of some of the species so the following names are not included in the descriptive part of the paper:

Erax comatus Bellardi was not identified in the material studied. It belongs to the carinatus group and is described as 25 millimeters in length.

Erax aper Walker very likely belongs to the carinatus group also but it was not identified. It was described from Mexico and may be one of the species mentioned in the paper but its description is indefinite.

I consider *Erax pumilus* Walker and *Erax disjunctus* Williston the same as *Eristicus nigripes* Bellardi. This species is considered in Trans. Am. Ent. Soc. XLIII, 297, under *Eicherax nigripes*. The insect is not mentioned either by Osten Sacken or Williston in their works on Central American Diptera.

Erax pavidus Williston, from Mexico, appears to be well characterized but it was not identified in the material studied.

Erax lascivus Wiedemann, *Asilus amarynceus* Walker, *Asilus flavofasciatus* Wiedemann, *Asilus macularis* Weidemann and *Asilus antiphon* Walker, most likely are all species of *Erax*. They have been reported from North America and most of them from South America also. Records of their occurrences are meager and they have not been identified in recent years.

LIST OF NORTH AMERICAN SPECIES OF ERAX WITH SYNONYMY.

The **barbatus** Group.

armatus new species.
barbatus Fabricius, Syst. Antl., 169, (Dasypogon), 1805.
  pogonias Wiedemann, Dipt. Exot., 198, (Asilus), 1821; Auss. Zw. I, 460, (Asilus), 1828.
  albibarbis Macquart, Dipt. Exot. I, 2, 118, 1838.
  cinerascens Bellardi, Saggio, II, 39, tab. II, fig. 10, 1861.
  tricolor Bellardi, Saggio, II, 40, tab. II, fig. 12, 1861.
  furax Williston, Trans. Am. Ent. Soc. XII, 67, 1885.
bicolor Bellardi, Saggio II, 47, 1861.
bimaculatus Bellardi, Saggio II, 45, tab. II, fig. 11, 1861.
cingulatus Bellardi, Saggio, II, 41, 1861.
grandis new species.
leucocomus Williston, Trans. Am. Ent. Soc. XII, 69, 1885.
quadrimaculatus Bellardi, Saggio, II, 44, tab. II, fig. 13, 1861.
sagax Williston, Biol. Centr. Am., Dipt., I, 324, 1901.
tagax Williston, Trans. Am. Ent. Soc. XII, 65, 1885.
  similis Williston, Trans. Am. Ent. Soc. XII, 68, 1885.
willistoni new species.
zonalis new species.

The **aridus** group.

aridus Williston, North Am. Fauna, No. 7, 254, 1893.
harveyi new species.
prattii new species.
snowi new species.
subpilosus Schaeffer, Jr. N. Y. Ent. Soc., XXIV, 67, 1916.

The **anomalus** group.

anomalus Bellardi, Saggio, II, 32, tab. II, fig. 7, 1861.
candidus Coquillett, Can. Ent. XXV, 176, (Efferia), 1893.
pernicis Coquillett, Can. Ent. XXV, 175, (Efferia), 1893.

The **aestuans** group.

aestuans Linneaus, Syst. Nat. XII, II, 1007, (Asilus), 1767.
  aestuans Fabricius, Syst. Antl., 164, (Dasypogon), 1805.
  niger Wiedemann, Dipt. Exot., 196; Auss. Zw., I, 460, (Asilus), 1821.
  macrolabis Wiedemann, Auss. Zw., I, 458, (Asilus), 1828.
  aestuans Macquart, Hist. Nat. Dipt., I, 312, (Asilus), 1834.
  incisuralis Macquart, Dipt. Exot., I, 2, 117, 1839.
  bastardi Macquart, Dipt. Exot., I, 2, 117, plate 9, fig. 7, 1839.
  tibialis Macquart, Dipt. Exot., I, 2, 118, 1839.
affnis Bellardi, Saggio, II, 41, 1861.
  marginatus Bellardi, Saggio, II, 46, 1861.
apicalis Wiedemann, Dipt. Exot., 191 (Asilus), 1821; Auss. Zw., I, 443, (Asilus), 1828.
  vicinus Macquart, Dipt. Exot., Supl. I, 85, 1846.
aurimystaceus new species.
belfragei new species.
femoratus Macquart, Dipt. Exot. I, 115, 1838.
fulvibarbis Macquart, Dipt. Exot., Supl. 3, 28, tab. 2, fig. 13, 1848.
haloesus Walker, List II, 405, (Asilus), 1849; List VII, 624, 1855.
kansensis new species.
loewii Bellardi, Saggio, Appendix, 21, tab. III, fig. 17, 1862.
  dolichogaster Williston, Biol. Centr. Am., Dipt. I, 326, tab. 6, fig. 6, 1901.
mexicanus new species.

nigrimystaceus Macquart, Dipt. Exot., Supl. 2, 1847.
nigritarsis new species.
portoricensis new species.
rufitibia Macquart, Dipt. Exot., Supl. 3, 42, tab. II, fig. 11, 1848.
fortis Walker, List. VII, 623, 1855.
slossonæ new species.
stylatus Fabricius, Syst. Ent. 795, (Asilus), 1775.
haitensis Macquart, Dipt. Exot., Supl. 3, 28, tab. II, fig. 10, 1848.
caudex Walker, List II, 404, (Asilus), 1849.
invarius Walker, Ins. Saund., Dipt. I, 131, 1851.
***tabescens** Banks, new species.

The **carinatus** group.

carinatus Bellardi, Saggio, II, 36, tab. II, fig. 9, 1861.
comatus Bellardi, Saggio, II, 34, 1861. Not identified in my material.
concinnatus Williston, Biol. Cent. Am., Dipt. I, 323, 1901.
costalis Williston, Trans. Am. Ent. Soc., XII, 64, 1885.
cressoni new species.
jubatus Williston, Trans. Am. Ent. Soc., XII, 66, 1885.
prolificus Osten Sacken, Biol. Cent. Am., Dipt. I, 202, 1887.
latrunculus Williston, Trans. Am. Ent. Soc., XII, 67, 1885.
parvulus Bellardi, Saggio, II, 35, tab. II, fig. 8, 1861.
subcupreus Schaeffer, Jr. N. Y. Ent. Soc., XXIV, 66, 1916.
unicolor Bellardi, Saggio, II, 37, 1861.

The **tuberculatus** group.

productus new species.
spiniventris new species.
tuberculatus Coquillett, Jr. N. Y. Ent. Soc., XII, 34, 1904.

The **rufibarbis** group.

bicaudatus new species.
rufibarbis Macquart, Dipt. Exot., I, 2, 116, 1838.
aestuans Wiedemann, Dipt. Exot., 200, (Asilus), 1821, (not *Linneaus*); Auss. Zw., I, 467, (Asilus), 1828.
completus Macquart, Dipt. Exot., I, 2, 117, tab. IX, fig. 9, 1838.
dascyllus Walker, List II, 401, (Asilus), 1849.
virginianus van der Wulp, Tijdschr. v. Entom. XXV, 109, tab. X, figs. 5 and 6, (*Proctacanthus*), 1882.
ravus Coquillett, Canadian Entomologist, XXV, 176, (*Efferia*), 1893.

The **stramineus** group.

argentifrons Hine, Ohio Naturalist, XI, 308, 1911.
argyrogaster Macquart, Dipt. Exot., supl. 1, 84, 1846.
argyrosoma Hine, Ohio Naturalist, XI, 310, 1911.
auripilus Hine, Ohio Jr. Science, XVII, 22, 1916.
aurivestitus new species.
californicus Schaeffer, Jr. N. Y. Ent. Soc. XXIV, 67, 1916.
canus Hine, Ohio. Jr. Sci. XVII, 22, 1916.
coquillettii new species.
dubius Williston, Trans. Am. Ent. Soc., XII, 64, 1885.
eximeus Bellardi, Saggio, II, 38, 1861.
inflatus Hine, Ohio Naturalist, XI, 310, 1911.

* Among a number of species received from the Museum of Comparative Zoology were two species which Dr. N. Banks had named and the descriptions in manuscript were turned over to me. The two species are Erax tabesuns and Erax texanus, and Dr. Banks is credited with these, although they are published for the first time in this paper.

interruptus Macquart, Hist. Nat. I, 310, (Asilus), 1834.
maculatus Macquart, Dipt. Exot., I, 2, 111, tab. IX, fig. 6, 1838.
lateralis Macquart, Dipt. Exot., I, 2, 116, 1838.
ambiguus Macquart, Dipt. Exot., supl. 1, 84, 1846.
villosus Bellardi, Saggio, II, 49, (*Eristicus*), 1861.
nemoralis Hine, Ohio Naturalist, XI, 311, 1911.
pallidulus Hine, Ohio Naturalist, XI, 309, 1911.
pilosus new species.
plenus Hine, Ohio Jr. Sci., XVII, 21, 1916.
rapax Osten Sacken, Biol. Centr. Am., Dipt., I, 201, 1887.
splendens Williston, Biol. Cent. Am., Dipt., I, 325, tab. VI, fig. 5, 1901.
stramineus Williston, Trans. Am. Ent. Soc., XII, 68, 1885.
texanus Banks, new species.
triton Osten Sacken, Biol. Centr. Amer., Dipt., I, 200, 1887.
truncatus Hine, Ohio Naturalist, XI, 309, 1911.
varipes Williston, Trans. Am. Ent. Soc., XII, 71, 1885.

KEY TO GROUPS OF ERAX.

1. Furcation of the third vein distinctly before the base of the second posterior cell making the second submarginal cell long 2
   Furcation of the third vein opposite or beyond the base of the second posterior cell 4
2. Three submarginal cells .... The **anomalus** group
   Two submarginal cells 3
3. Rear of thorax and scutellum with abundance of bristles, male abdominal segments six and seven silvery, female with tip of oviduct from above furcate .... The **rufibarbis** group
   Male abdomen usually with several segments silvery, female with tip of oviduct from above never divided. Male, except in a very few cases, with one or more abdominal segments bearing long white hair parted at the middle and directed outward .... The **stramineus** group
4. Posterior branch of the third vein curved backward at tip, meeting the costa at or beyond the apex of the wing .... The **aestuans** group
   Posterior branch of the third vein curved forward, meeting the costa plainly before the apex of the wing 5
5. Mesothorax compressed anteriorly and with a conspicuous crest of erect hairs on the mid-dorsal line .... The **carinatus** group
   Mesothorax broadly rounded above and without a conspicuous crest of hairs.. 6
6. Mesothorax with numerous bristly hairs which are unusually long, scutellum conspicuously hairy and with numerous marginal bristles..The **aridus** group
   Mesothorax with very short hair anteriorly, a few rather prominent bristles posteriorly. Scutellum with short hair on the disc and usually with not more than half a dozen bristles on its margin 7
7. Male with ventral prominences on abdominal segments four, five and six, small slender species .... The **tuberculatus** group
   Male abdomen without ventral prominences usually large or medium sized, robust species .... The **barbatus** group

The **barbatus** Group.

The members of this group have a broad mesothorax, quite evenly curved, short-haired all over, especially anterior to the transverse suture. Only a few prominent bristles above the attachment of the wings and posteriorly. Scutellum short-haired on the disc, and usually with not more than half a dozen bristles on the margin, although occasional specimens may have one or two more than this number, in most cases there are less. Branching of the third vein never anterior to the base of the second posterior cell, occasionally it is opposite the base of this cell, but in nearly all cases it is plainly beyond, making the second submarginal cell short. The posterior branch of the third vein bends forward, and reaches the costa distinctly before the apex of the wing.

In some species the male has the costa thickened and expanded on the anterior margin, somewhat before the apex, but in other species this is not the case.

A species which is typical of this group is what in recent years has been called *albibarbis*, but here it is considered the same as *barbatus* which is an older name as indicated in the list of species on another page.

1. Hypopygium small or of normal size, medium sized to small species, usually of slender build, male costa not at all or only very slightly expanded, female with each abdominal segment black, with posterior gray border of various widths according to species....2
   Hypopygium distinctly enlarged, large to very large species, male costa rather conspicuously thickened and expanded, female abdomen variously marked, but usually the segments are not black with posterior gray borders, although this is the case in at least two species....5
   Hypopygium distinctly enlarged, costa not at all thickened and expanded, mystax straw yellow in both sexes, bristles of the thorax and scutellum pale, abdomen uniformly yellowish gray pollinose, male with the apical abdominal segments partly or wholly silvery........**leucocomus** Williston
2. Gray bands of the abdomen regular and wide, approaching the width of the black intervals between them, hypopygium red............**zonatus** n. sp.
   Hypopygium black, gray abdominal bands irregular or very narrow.......3
3. Mystax pale, sometimes with a few black bristles on upper margin, **barbatus** Fabr.
   Mystax largely black with pale hairs and bristles intermixed 4
4. Sixth and seventh segments of male abdomen silvery, pale bands of the abdomen brownish gray, with front margin more or less irregular, **cingulatus** Bellardi
   Fifth. sixth and seventh segments of male abdomen silvery; pale bands of the abdomen silvery, regular and narrow.............**willistoni** n. sp.
5. Male hind tibiae with an abnormal enlargement....6
   Male hind tibiae normal....8
6. Wings quite distinctly brown....**sagax** Williston
   Wings hyaline....7
7. Apical third of the male tibia enlarged..................**tagax** Williston
   Apical half or more of male tibia enlarged................**armatus** Hine
8. Male seventh abdominal segment entirely silvery dorsally; female fifth abdominal segment not silvery....9
   Male seventh abdominal segment clear black on the greater part of the dorsum; female fifth abdominal segment broadly silvery on each side, with a black stripe on the middle of the dorsum....10

9. Wings hyaline, not usually large........................**bicolor** Bellardi
Wings brownish, especially toward the apex; very large species..**grandis** n. sp.
10. Mystax straw yellow with a few black bristles above, wings pale yellowish brown..**bimaculatus** Bellardi
Mystax black with a few pale bristles intermixed; wings fuscous, more apparent towards the apex.....................**quadrimaculatus** Bellardi

Erax barbatus Fabricius.

Length 13 to 20 millimeters. Male. All vestiture of the head white to pale yellowish. Quite often a few black bristles in the mystax and occasionally on the palpi. Thorax pale pollinose, not always of the same shade, markings very obscure, anteriorly with short pile variable in color, posteriorly with a number of black pale bristles. Scutellum with sparse pale pile on the disc and a few black or pale bristles on the margin. Femora black in ground color obscured by white pollen and hair, apex of each tibia and whole of tarsi largely black, tibiæ otherwise pale yellowish, bristles of the legs variable from black to pale, wings slightly yellowish, nearly hyaline, costa not dilated, anterior branch of the third vein with a distinct stump variable in length in different specimens, basal section almost in direct line with the cross vein at the base of second posterior cell. Abdomen dorsally, first and second segments pale pollinose, usually a rather small rounded blackish spot on each side of the second; third, fourth and fifth largely black with posterior margins and often median stripe pale pollinose; sixth and seventh silvery. Hypopygium black. See Figures 2 and 8.

Female colored like the male, abdominal segments six and seven colored like the preceding in most cases, but sometimes the segments are nearly wholly gray pollinose, oviduct shining black.

This species is the most widely distributed of any of the genus. It ranges from Guatemala and Lower California to Washington and New England and often is the first of the genus taken in any locality within its range.

The uniform color of the thorax without apparent markings and the two rows of black spots on the abdomen make its determination easy. Although the two longitudinal rows of black abdominal spots are present in most cases there is variation, some specimens having these spots much reduced while others have them enlarged until nearly the whole abdomen is black. The two basal segments, however, most always are uniformly gray and the other segments have at least a narrow middorsal stripe and posterior border on each, the same color.

The possibility of more than one species in the material used has been considered but it does not appear possible to find characters for satisfactory separation, so it is preferable to include all in a single species.

Erax bicolor Bellardi.

Total length 21 to 26 millimeters; vestiture of the head largely yellowish white, some black bristles in the mystax; bristles of the palpi almost wholly black. Whole body nearly uniformly gray pollinose, mid-dorsal stripe of the thorax quite plainly black and divided lengthwise by a gray interval. In some specimens rather obscure darker spots on some of the abdominal segments. Wings hyaline costal border dilated, furcation of the third vein plainly beyond the base of the second posterior cell, basal three-fourths or more of the tibiæ pale yellowish, otherwise legs black with black bristles. Sixth and seventh abdominal segments silvery, hypopygium large and black. See Figure 9.

Female colored like the male, except abdominal segments six and seven are velvety black. Oviduct black, about as long as segments four to seven.

Habitat: Mexico, Texas, Mississippi, New Mexico and Arizona. Twenty-four specimens.

Bellardi described the species from a female and mentioned the black sixth and seventh abdominal segments which seems to be a peculiarity of this species. It is more evident in some specimens than others.

Erax willistoni n. sp.

Male. Total length 22 millimeters. Very dark colored species; mystax black with a few pale hairs intermixed, beard white, palpi with black bristly hairs. Thorax thinly gray pollinose, mid-dorsal stripe and irregular spots on either side black, with black hair and bristles, scutellum gray pollinose with pale hairs on the disc and about eight black bristles on the margin. Wings nearly hyaline, very slightly tinged with brown on apical half; costa somewhat dilated, branching of the third vein beyond the base of the second posterior cell, stump very short. Legs with black bristles and pale hairs, extreme apexes of femora, tibiæ and tarsi entirely dark reddish brown, remainder of femora black. Abdominal segments two, three and four black above, narrow posterior margin and sides gray pollinose, segments five, six and seven silvery, hypopygium elongate, emarginate at apex, black with black vestiture. See Figure 7.

Female. Total length 23 millimeters. Colored like the male with segments five, six and seven like those that precede them, ovipositor black, as long as the last four abdominal segments.

Type male and allotype, on the same pin, collected at Williams, Arizona, July 21, by H. Barber. Deposited in the U. S. National Museum. Five other specimens from Colorado, Arizona and Chihuahua, Mexico, by Tucker, Barber and Townsend.

This species looks like æstuans but the wing venation, color of the legs and the male genitalia characterize it. It is the only species of its group with the femora reddish brown at the apexes although some specimens do not show the character very plainly.

Erax cingulatus Bellardi.

Total length 20 to 25 millimeters. Male. Mystax largely black, but intermixed with pale yellowish hairs; beard pale yellowish; palpi with numerous black bristly hairs. Much of the thorax and abdomen brownish pollinose, thorax with a wide mid-dorsal stripe and spots on either side black, vestiture mostly black, but a few pale hairs posteriorly, scutellum and extending to the posterior part of the mesothorax ash gray, conspicuously contrasting in color with the rest of the thorax, wings tinted with brownish, costa very slightly dilated, furcation of the third vein distinctly beyond the base of second posterior cell, stump shorter than the basal section, three-fourths or more of tibiæ from bases, pale yellowish, otherwise legs black, except some of the basal tibial segments which are dark brown. Some of the bristles of the legs are pale in some specimens, but most of them are black, abdominal segments two, three, four and five black anteriorly and pale brownish pollinose posteriorly, the divisions between the colors irregular and not sharply defined, segments six and seven silvery. Hypopygium black with black vestiture, rather large. Figure 34.

Female colored like the male except abdominal segments six and seven are like those that precede them. Ovipositor black, slightly longer than the last three abdominal segments.

Seven specimens from Cuernavaca, Mexico, collected by D. L. Crawford.

The ash-colored scutellum and space before it contrasting with the rest of the thorax is characteristic of this species, but only well preserved specimens show it. There are only two to four black bristles on the margin of the scutellum.

Erax grandis n. sp.

Male. Total length 33 millimeters. Mystax composed of numerous yellowish gray hairs and black bristles, beard pale yellowish gray, palpi with black and pale hairs, thorax gray pollinose with unusual markings, scutellum with black hairs on its disc and four black bristles on its margin, femora, apexes of tibiæ and tarsi black, remainder of tibiæ pale yellow, wings slightly brownish, costa distinctly dilated, furcation of third vein plainly beyond the base of the second posterior cell, stump very short, two, three, four and five abdominal segments black above, with narrow posterior margin and sides gray, segments six and seven silvery. Hypopygium large, black with black vestiture.

Female. Total length 31 millimeters with tip of ovipositor broken off, probably 34 or 35 millimeters when complete, colored like the male, but segments six and seven not silvery, stump of the anterior branch of the third vein much longer than in the other sex.

Type: Male and allotype, from Round Mountain, Texas, deposited in the museum of the Philadelphia Academy of Natural Sciences.

This is the largest *Erax* I have ever seen. It suggests bicolor but aside from its being much larger the costa is more strongly dilated, the disc of the scutellum has black hair instead of white, and the male genitalia are different.

Erax zonatus n. sp.

Male. Total length 16 millimeters. Vestiture of the head largely white, several black bristles in the mystax and numerous black hairs on the palpi. Tibiæ red except at extreme apex, tarsi largely red, but somewhat darker than the tibiæ and furnished with numerous black bristles, femora black. Thorax quite uniformly yellowish gray pollinose with the usual marking very obscurely shown. Wings very slightly tinged with yellowish, nearly hyaline, costa just a little dilated, branching of the third vein plainly beyond the base of second posterior cell, stump slightly longer than the basal section. Abdomen with four black bands as follows: One on the middle of the second segment and one on each anterior margin of segments three, four and five. These black bands all are wider than the gray bands following them. Segments six and seven silvery. Hypopygium red, prominent ventrally, more so in appearance because of a ventral tuft of chestnut brown hairs.

Female. Total length 18 millimeters. Colored like the male except the sixth abdominal segment is banded with black like five, and seven is black with a very narrow gray posterior margin, ovipositor black, about as long as abdominal segments five, six and seven.

Type: Male and allotype from Southern Arizona, F. H. Snow, August, 1902. Collection of the author. Ten other specimens, some of them from the collection of the Academy of Natural Sciences, Philadelphia. Habitat, San Antonio Canyon, California, Southern Arizona and Alamogordo, New Mexico.

Easily known from all species of its group by the zonate appearance of the abdomen, and the prominent array of ventral hairs on the hypopygium, most conspicuous basally.

Erax armatus Hine.

There are three species of Erax with the hind tibiæ modified in the male. All are larger than the average. In the male the furcation of the third vein is beyond the base of the second posterior cell, while in the females it is usually about opposite the base of that cell. Stump

of the anterior branch always present. The females are easily associated with the males, but have no very good characters for distinguishing them from others of the same sex. The wings are hyaline in armatus, at least the yellowish tinge is hardly evident. The tibia of the male shows an angular prominence posteriorly, somewhat nearer its base than its apex, the female has the first five abdominal segments rather densely gray pollinose, with rounded black spots above on two, three, four and five; segment six is nearly all black above and seven is entirely black. Femora, tarsi and apexes of tibiæ black, basal three-fourths or more of each tibia pale yellow. Total length 30 to 32 millimeters.

Ten specimens from Davis Mountains (F. M. Gaige) Cotulla (F. C. Pratt) and Uvalde, Texas. Taken in June and July.

Erax sagax Williston.

Total length 25 to 27 millimeters. Wing wide and conspicuously light brown all over in both sexes; male with the hind tibia suddenly enlarged beyond the middle of its length; both sexes with silvery markings on the abdomen. In the male, segments two and three are narrowly silvery on the sides, four, five and six are largely silvery, but four has a rather large black triangular spot above and five has a narrow black marking above anteriorly, six entirely silvery, seven black above with narrow sides silvery.

Female with segments two, three, four and five silvery at the sides; this color is extended dorsally on the hind margin of three and on the whole of four and five, but in no case does it meet above so there is a conspicuous black space left dorsally on each segment; six and seven nearly entirely black. The femora are red apically in both sexes, and posteriorly in the female, in the specimens at hand.

Three specimens from Guadalajara, Mexico, June 24, 1903, collected by McClendon.

Erax tagax Williston.

Total length 28 to 30 millimeters. Wing very pale brownish. Male hind tibia with a distinct prominence posteriorly near distal third and a conspicuous patch of black pile anteriorly just opposite and extending to apex. Abdominal segments of the male two, three, four and five black with narrow sides and posterior margin silvery white pollinose, six wholly silvery, seven mostly silvery, but with posterior margin above dark. Female, segments two, three, four, five and six black, with sides and narrow posterior margin white pollinose, seven black, oviduct black not much longer than abdominal segments six and seven. Femora black in the male and mostly redish posteriorly in the female in the specimens at hand.

A dozen specimens from Arizona.

There is no record that *Erax similis* has been recognized since it was described by Williston and we have good reason to believe that it is the female of *tagax*.

Erax leucocomus Williston.

A large pale species with bristles and hairs of head, thorax and abdomen all pale yellowish; legs usually with black femora and black bristles throughout; wings delicate yellowish, veins quite distinctly yellow on the basal part. Total length 25 to 30 millimeters. Male wing with the furcation of the third vein beyond the base of the second posterior cell, stump about as long as the basal section, costa not dilated in the least. Hypopygium large from dorsal view gradually widened toward the tip, where it is much wider than in other species of its group. The abdomen in both sexes is pale yellowish gray without markings, but somewhat changeable according to the direction from which it is viewed. In the male, segments six and seven may be said to be silvery and in the female segment seven is somewhat darker than the others. Oviduct black. Nearly as long as the last three abdominal segments.

Ten specimens from Western Kansas, collected by F. X. Williams and one from Dallas, Texas, taken September 5, 1905, by F. C. Bishop.

The species is very distinct and readily recognized but appears to be rare and I had two species questionably referred to *leucocomus* before I procured it. It would not be strange if some specimens would have some black bristles on the body. It is well adapted to life on the sand on account of its color.

Erax quadrimaculatus Bellardi.

Total length 28 to 34 millimeters. Mystax rather sparse, composed largely of black bristles with a few pale ones and pale hairs intermixed, beard nearly white. Whole body black and appearing darker than other species of Erax. Thorax very sparsely gray pollinose with black bristles and hairs, scutellum with short black hairs on the disc and two to four black bristles on the margin; femora, tarsi and apexes of the tibiæ black, remainder of tibiæ pale yellow, wings uniformly fuscous all over, costa only slightly dilated in the male, furcation of the third vein clearly beyond the base of the second posterior cell. In the male abdominal segments two, three, four and five with sides narrowly gray pollinose, extended dorsally on the posterior margin of each, but not uniting across the dorsum; segment six silvery on each side, widest before leaving a black dorsal triangular spot with its base on the posterior margin; segment seven similar, but the silvery areas much reduced and the black consequently extended. Female segments two, three and four as in the male, five conspicuously silvery on each side, black on the mid-dorsum; six and seven velvety black, oviduct black, hardly as long as abdominal segments five, six and seven.

Several specimens from Colombia, South America, from the Carnegie Museum of Pittsburgh. Other specimens from Mexico.

Erax bimaculatus Bellardi.

Total length 25 to 28 millimeters. Mystax and beard pale yellow, the former with a few black bristles above; thorax brown pollinose with the usual markings; wings yellowish, costa of male distinctly dilated, femora black, remainder of legs yellowish red with black bristles. Abdomen colored much as in quadrimaculatus in the male segments four and five entirely silvery, or at most with a very narrow mid-dorsal stripe, segment seven silvery on front margin and on the sides, black otherwise, female with abdominal segments two, three and four white pollinose on the sides, fifth white with the exception of a mid-dorsal stripe, sixth and seventh velvety black, oviduct shining black.

The yellow mystax and beard readily separates this species from *quadrimaculatus*. The two species are entirely distinct although similarly colored.

Several specimens from Guadalajara, Mexico, collected by McClendon, and from Cuernavace, Mexico, collected by D. L. Crawford.

The **aridus** Group.

A few species from the more or less arid regions of western United States are much like members of the stramineus group, but the branching of the third vein is almost exactly opposite the base of the second posterior cell. The following key may be used to separate the species.

1. Mystax straw yellow 2
   Mystax white. 3
2. Male abdominal segments six and seven, silvery. . . . . **harveyi** n. sp.
   Male abdominal segments four, five, six and seven silvery. Four more or less black on the mid-dorsal line. . . . . **snowi** n. sp.
3. Hypopygium from dorsal view plainly widened towards apex where it is distinctly wider than at base. . . . . **prattii** n. sp.
   Hypopygium not or but very slightly wider at apex than at base. 4
4. Bristles of the body and legs nearly all white, male first and second abdominal segments black hairy. . . . . **subpilosus** Schaeffer
   Male first and second abdominal segments white hairy. . . **aridus** Williston

Erax harveyi n. sp.

Male. Total length 18 millimeters. Mystax, beard, ocellar and occipito-orbital bristles pale straw yellow, palpi black and yellow haired, anterior part of dorsum of mesothorax black haired, remainder of thorax with pale vestiture, scutellum with numerous pale yellow marginal bristles; wings hyaline, furcation of the third vein exactly opposite the base of the second posterior cell, stump about as long as the basal section; legs faded reddish, mostly with pale vestiture, but an occasional black bristle, femora quite distinctly darker than the other parts. Abdomen pale haired all over, general color dark, thinly

gray pollinose, more dense in some places than others giving a mottled appearance from some views; sixth and seventh segments silvery, hypopygium rather small, dark colored from dorsal view, sides nearly parallel, angular at extreme apex.

Female. Total length 21 millimeters. Colored like the male. Sixth and seventh abdominal segments, from side view, wedge shaped at tip, from dorsal view not furcate apically.

Type: Male and allotype, from Vernon, B. C., August 11 and 15, 1904. Collected by the late Captain R. Valentine Harvey for whom the species is named.

This species suggests *bicaudatus* but the structure of the oviduct is very different and the second submarginal cell is shorter.

Erax snowi n. sp.

Male. Total length 22 millimeters. All the bristles of the head except four bristles near the ocelli pale yellowish tinged, thoracic dorsum and disc of scutellum black hairy, bristles near the wing roots and on the margin of the scutellum pale yellowish, pleuræ with pale hair, legs largely black with abundant long pale hair and black and pale bristles, basal half of each front and middle tibia and basal fourth of each hind tibia reddish, although not conspicuously so. Wings faintly yellowish hyaline, furcation of the third vein nearly opposite the base of the second posterior cell, stump about the length of the basal section, first three abdominal segments mostly black, thinly yellowish pollinose laterally, with black hair above and pale yellowish and rather long hairs at the sides; fourth segment narrow black before and on the middle of the dorsum, white pollinose and long white haired laterally, fifty, sixth and seventh segments silvery and with a few short white hairs. Hypopygium black, mostly with pale vestiture, of medium size.

Female. Size and coloration very nearly as in the male. Abdomen entirely yellowish gray pollinose and pale haired, from some views more or less shining; oviduct black, scarcely as long as the last three abdominal segments.

Type: Male and allotype, from Clark County, Kansas, 1962 feet elevation, taken in May by F. H. Snow, for whom the species is named. In the author's collection. More than fifty other specimens from Kansas, Colorado, New Mexico and Texas, show some variation in size, and a little in color of bristles, but may be said to be quite uniform.

Some specimens have more black bristles on the posterior part of the mesonotum and on the margin of the scutellum than the type.

The color of the abdomen distinguishes the species from all others except *plenus* which has very different male genitalia.

Erax aridus Williston.

The female type of aridus is in the National Museum. There does not appear to be any male specimens at hand. The species is peculiar in being very hairy and bristly and Williston described it as belonging near latrunculus, but it surely is very distinct from that species. True there is a row of rather long black hairs in the middle of the anterior part of the dorsum of the mesothorax, but the thorax is not compressed and it is almost sure that when the male of aridus is finally located it will not have a dilated costa which is always present in the carinatus group. Palpi with black hair, vestiture of remainder of head pale, mesothoracic dorsum with black hair, scutellum with light hair, bristles near the wing bases pale, pleuræ pale haired, legs with abundance of long pale hairs, and mostly pale bristles, legs black, base of each tibia with just a suggestion of reddish, wings hyaline, furcation of the third vein nearly opposite the base of the second posterior cell, stump distinctly longer than the basal section, abdomen black, gray pollinose, more plainly so laterally and on the narrow posterior border of each segment. Oviduct black, short, only a little longer than the last two abdominal segments.

The short oviduct readily separates *aridus* from what is considered as the female of *subpilosus* a nearly related species. For a time the possibility of the type of *subpilosus* being the male of *aridus* was considered but there seems to be good reason for separating them as distinct. Length about 25 millimeters.

Williston's type was taken by the Death Valley Expedition in April, 1891.

Erax prattii n. sp.

Male. Total length 16 millimeters. Mystax and beard white, palpi with black bristles, front mostly with pale hairs, several bristles near the ocelli, some black and the others yellow, occipito-orbital bristles pale yellowish. Bristles and hairs of the mesothoracic dorsum black, pleuræ white hairy; legs abundantly long white hairy and with black and pale bristles, femora black, tibiæ and tarsi mostly pale brownish; wings hyaline, costa not at all dilated, branching of the third vein almost exactly opposite the base of the second posterior cell, stump scarcely as long as the basal section. Abdominal segments one to five inclusive black, each with a narrow gray border of uniform width, segments six and seven silvery. Hypopygium from dorsal view gradually widened from base to apex, where it is nearly truncate and distinctly wider than in most other species. See Figure 13.

Male type from Laredo, Texas, November 25, 1905. Collected by F. C. Pratt, from whom the specimen was procured. Collection of the author.

The size and the width of hypopygium make it easy to determine this species.

Erax subpilosus Shaeffer.

Male. Length 22 millimeters. Head grayish-white pollinose, beard and mystax white, occipito-orbital bristles white. Thorax black, faintly grayish-brown pollinose, mid-dorsal stripe faint; dorsum sparsely covered with short, black hairs, which are longer apically. Scutellum with black hairs and bristles, some of which are white apically. Pleuræ faintly pollinose, covered not densely with moderate long white hairs. Abdomen black, first to third segments with black hairs, longer at sides, fourth segment with long white hairs intermixed with black hairs, which are directed outwardly; fifth segment white pollinose and with shorter white hairs, sixth and seventh segments densely white pollinose; apical margins of segments two to five grayish pollinose. Venter grayish-white pollinose, covered with long, white hairs. Hypopygium black, clothed with shorter white hairs. Wings pure hyaline. Legs entirely black, clothed with shorter and longer white hairs. Furcation of the third vein almost directly opposite the base of the second posterior cell, stump rather short.

Female. Total length 22 to 27 millimeters. Colored much as in the male, abdomen black, narrowly gray pollinose on the sides and posterior margin of each segment, hair of the abdomen largely white, but some black, especially on the dorsum. Oviduct rather long, longer than the last three abdominal segments.

Type: Male, in the Brooklyn Museum of Arts and Sciences, is labeled Beaver Creek Hills, Beaver County, Utah. Other specimens at hand from Reno, Nevada, New Mexico and California. The California specimens are at the Museum of Comparative Zoology at Cambridge, Mass., and are from the collections of Loew and Osten Sacken. Loew gave the manuscript name lencotrichus to the species.

The predominance of pure white bristles of the legs is a distinctive character and easily separates it from most related forms. The bristles of the feet especially practically all are white.

Williston's *aridus* is much like subpilosus in general appearance but the latter has a much longer oviduct. The color of the vestiture of the abdomen is more or less variable in subpilosus.

The **anomalus** Group.

Three species belong to the group with three submarginal cells normally. They are all rather light colored and inhabitants of more or less arid regions. Coquillett has proposed the genus *Efferia* for the reception of these species, but usually it is considered a synonym of *Erax*. The furcation of the third vein occurs about midway between the base of the second posterior cell and the anterior cross vein. Costa not dilated.

1. Bristles of the palpi, scutellum and upper part of the occiput, black, **anomalus** Bellardi
   Bristles of the mystax, palpi, upper part of the occiput and usually of the scutellum, pale 2
2. Male abdomen with white hairs parted at the middle and directed outward. **candidus** Coquillett
   Male abdomen gray pollinose and without white hair parted at the middle and directed outward .... **pernicis** Coquillett

Erax anomalus Bell.

Male. Total length 18 to 26 millimeters. Mystax varying from white to pale yellowish, beard white, palpi sometimes clothed with white hair and sometimes with black, thorax with white and black hair and black bristles, scutellum with white pile on its disc and a row of black bristles on its margin. The color of hair and bristles appear to be somewhat variable, however; wings hyaline. Femora dark, usually black, anteriorly and reddish posteriorly, tibia reddish, darker near apex, tarsi darker than the tibiæ. Abdomen largely silvery pollinose, segments two to six with long silvery hair parted at the middle and directed outward. Hypopygium shown from side in Figure 10. Wing shown in Figure 5.

Female. Abdomen above with a prominent black triangle on each segment with its base on the anterior margin and its apex not quite reaching the posterior border, otherwise gray pollinose. Some variation in the extent of the black occurs however. Oviduct almost as long as abdominal segments five, six and seven.

Range: Kansas to Texas and Mexico and westward.

Erax candidus Coquillett.

Total length 15 to 30 millimeters. Body in both sexes white pollinose, mystax and beard silky white, palpi with white hair, femora, apexes of tibiæ, and tarsi black, basal three-fourths of each tibia sometimes pale yellow, sometimes darker. Legs everywhere with white hair and an occasional black bristle. Male abdominal segments two to four with white hair parted at middle and directed outward, segments six and seven without such hair. Hypopygium shown from the side in Figure 11.

Range: Kansas, New Mexico, Arizona and California.

Erax pernicis Coquillett.

Total length 15 to 20 millimeters. Known from candidus by being less distinctly white pollinose, the male is devoid of long hair on the abdomen. The species averages smaller and the hypopygium is different. See Figure 12.

Specimens from Arizona and California.

The **aestuans** Group.

The species of this group have been divided into two parts for the purpose of the present paper. So far only one species has been found to be common to both the North American continent and to the West Indies. This being the case the two faunas are separated and a key given for each in order to facilitate determination.

The species falling in the group are recognized at once by the peculiar posterior branch of the third vein which, instead of curving forward at its apex, as in other groups, curves backward and reaches the costa near or beyond the apex of the wing. The branching of the third vein occurs beyond the base of the second posterior cell. The following key is offered as an aid in separating the species of the North American Continent.

1. Legs entirely shining black 2
   At least the tibiae distinctly red 4
2. Wings hyaline, male costa normal .... **slossonæ** n. sp.
   Wings distinctly pale brownish, more pronounced on apical half; male costa plainly expanded 3
3. Total length, 20 millimeters or over, hypopygium longer than abdominal segments five, six and seven .... **loewii** Bellardi
   Total length not over 15 millimeters, hypopygium tumid .... **mexicanus** n. sp.
4. Hypopygium from side view, most prominent apically on upper half, small species 5
   Hypopygium most prominent at middle apically, medium to large species .. 6
5. Mystax yellow .... **aurimystaceus** n. sp.
   Mystax black with gray hairs intermixed .... **belfragei** n. sp.
6. Femora red apically .... **affinis** Bellardi
   Femora black 7
7. Costa more or less dilated in the male, usually large robust species. Mystax black, intermixed with white hairs 8
   Costa not at all dilated, medium sized slender species. Mystax with black bristles above and pale yellow hairs below. Three species difficult to separate. Refer to figures of hypopygiums 10
8. Hypopygium unusually large, conspicuously pilose below (Cuban species, one record from Florida), mystax with a few black bristles .. **stylatus** Fabr.
   Hypopygium of normal size. Mystax composed mostly of black bristles 9
9. Total length 25 millimeters or more, the largest species of the aestuans group .... **femoratus** Macquart
   Total length 23 millimeters or less, tibiae dark brown, general body color blacker than usual .... **aestuans** Linn.
10. Hypopygium with a tuft of dense pile below at apex ... **tabescens** Banks, n. sp.
    Hypopygium without such a tuft 11
11. Apical part of hypopygium narrowed and curved downward, with a tooth-like prominence above .... **apicalis** Wiedemann
    Apical part of hypopygium nearly as wide as the preceding part, **kansensis** n. sp.

Erax belfragei n. sp.

Male. Total length 10 millimeters. Mystax largely black though with some gray intermixed; palpi with black pile, beard gray, thorax gray pollinose with the usual black markings, hair and bristles mostly black, although some gray intermixed on posterior part and on the scutellum. Wings slightly fumose, a little more intense toward the apex, costal border not dilated in the least, stump on anterior branch of the third vein not quite as long as the connecting vein, perhaps the length of this stump will be variable however. Femora entirely black, narrow apexes of tibiæ and entire tarsi black. Abdomen dark, largely gray pollinose, dorsum of segments two to four black before the narrow posterior gray borders, segments five, six and seven silvery; genitalia elongate, sides nearly parallel, widened somewhat on posterior third and notched at tip. Figure 21.

Female colored like the male, stump of anterior branch of the third vein fully as long as abdominal segments four to seven inclusive.

Type: Male and allotype bearing the label "Texas," Belfrage. In the U. S. National Museum.

Most closely related to *aurimystaceus* but the color and male genitalia are clearly distinctive.

Erax slossonæ n. sp.

Male. Total length 14 millimeters. Mystax prominent, mostly white, but with a number of black bristles in the upper part, palpi with black pile, beard white, dorsum of the mesothorax with long black hair and bristles, scutellum with white hairs on its disc and a few black bristles on its margin. Wings hyaline, very short, much shorter than the connecting vein; legs entirely shining black, clothed with white and black hair and black bristles. Abdominal segments two, three and four black before the narrow, gray pollinose, hind-margins, dorsally. Narrow posterior margin of four, all of five, six and seven silvery; genitalia shining black, with black hair, widened from the side gradually to middle, then narrowed gradually and with a rather large extension apically partly cut off by incisions above and below. See Figure 25.

Male type from Jacksonville, Florida, collected by Mrs. Anna T. Slosson and forwarded by C. W. Johnson.

Very distinct from other species of its group from Eastern United States on account of its entirely shining black legs. The male genitalia distinguish it readily.

Erax affinis Bellardi.

Total length 17 millimeters. Mystax black and white mixed, palpi with black and white hairs and bristles, beard white, thorax yellowish brown pollinose with the usual black markings; scutellum white pilose with black or white marginal bristles; legs variable to some extent, femora usually black on basal three-fourths and red at apex,

but nearly all red in some specimens, although all I have seen have at least a trace of black on the front side of each; tibiæ red, darker apically, tarsi dark red with black bristles. Wings yellowish, slightly more intense toward apex, male costa slightly dilated. Abdomen dark, gray pollinose on venter and sides. Male with segments six and seven silvery, genitalia shining black with an extension apically attached below and directed upward. See Figure 28.

Female colored like the male, except femora are more extensively red than in the other sex in some of the specimens studied.

The females taken in the same locality as the males, as well as other females before me, agree with Bellardi's description of *marginatus*. He described *affinis* from a male and *marginatus* from a female. It appears that they are sexes of the same species.

Specimens from Mexico and from Bonda, Columbia, S. A.

Erax kansensis n. sp.

Total length 17 millimeters. Mystax largely pale straw yellow, but with some black bristles intermixed, palpi clothed with black hair, beard nearly white, though with a tinge of straw color. Thorax above with black and white pile and some black bristles; wings hyaline, a tinge of brownish in the apical part of the marginal cell, costa not dilated, anterior branch of the third vein with only an indication of a stump; femora, apexes of tibiæ and entire tarsi black, basal three-fourths or more of tibiæ bright yellow; abdomen dark in ground color, largely thinly gray pollinose, seventh segment just slightly silvery. Male genitalia narrow; not long, narrowed suddenly and bearing at the tip an angular extension. See Figure 19.

Female colored like the male, genitalia rather wide and somewhat longer than abdominal segments five, six and seven.

Type: Male and allotype, from Clark County, Kansas, elevation 1962 feet. F. H. Snow. In the author's collection. Easily identified by the male genitalia. Most closely related to apicalis.

Erax aurimystaceus n. sp.

Length of male 13 millimeters. Mystax rather large, golden yellow, beard paler yellow. Thoracic dorsum with numerous rather long black hairs and some pale yellowish hairs intermixed on the posterior part where they are distinctly longer than on anterior part. Scutellum with numerous pale hairs on the disc and two black bristles apically. Wings uniformly very pale yellowish hyaline, femora entirely deep black, tibiæ bright yellow with extreme apexes black, tarsi darker, but mostly reddish, with numerous black bristles. Legs clothed with fine pale hairs and black bristles. Abdomen yellowish gray pollinose, segments two to five each with a large quadrate black spot above, segments six

and seven silvery. Hypopygium shining black with abundance of fine black hair; from side view notched at tip and quite different from other species of its group. Refer to Figure 22.

Holotype: Male from Clark County, Kansas, F. H. Snow. Several males and females from Clark, Ellis, Grove and Ness Counties, Kansas, mostly taken in July.

The female differs from the male only in sexual characters. The oviduct is distinctly shorter and stouter than in aestuans and apicalis, being only about as long as the last three abdominal segments.

The species is entirely distinct and easily recognized by its small size, yellow mystax and male and female genitalia. The bristles at the apex of the scutellum are subject to slight variation in number and in some specimens are golden yellow instead of black.

Erax mexicanus n. sp.

Male. Total length 12 millimeters. Mystax black above, pale yellow below, palpi with black bristles, beard pale yellowish, wings nearly uniform brownish, costal margin very slightly dilated, stump of anterior branch of the third vein much shorter than the connecting vein; legs black in all their parts. Abdomen black with yellow hairs, segments five, six and seven silvery, venter of last abdominal produced backward the length of more than two abdominal segments and with several black hairs at the tip. Genitalia black, shining, tumid, suddenly narrowed before the apex, produced into a distinct tubercle. See Figure 27.

Female colored like the male; stump of the anterior branch of the third vein a little longer than in the male, but not much longer than the basal section. Genitalia somewhat longer than segments five, six and seven.

Male type and allotype from Tapachula, Chiapas, collected by D. H. Crawford. Three other males from the same locality. One male is somewhat larger than the type and has only abdominal segments six and seven silvery.

The small size, black legs and peculiar male genitalia serve to distinguish the species.

Erax femoratus Macquart.

Total length, male and female, 26 to 30 millimeters. Mystax largely black, but with white hairs intermixed, beard pale, palpi black hairy, occipito-orbital bristles black; mesothoracic dorsum before with very short black hair, several strong black bristles above the roots of the wings and before the scutellum; scutellum with fine white hairs

on the disc and several strong black bristles on its margin, femora black, tibiæ and tarsi dark red, apices of tibiæ and tarsi darker in some specimens than others; wings hyaline, male costa slightly dilated. Male abdomen, first four segments gray on the sides and narrow hind margin; segments five, six and seven silvery, hypopygium black and largely black hairy. Female abdomen with each segment gray on sides and narrow posterior border, oviduct nearly as long as the last four abdominal segments.

From Slidell, Louisiana, and from Florida.

Much like *æstuans* and there is some doubt in regard to its distinctness from that species, but the large size and robust form give it quite a different appearance. The specimens I collected at Slidell, Louisiana, were taken from the trunks of trees.

Erax aestuans Linne.

Variable in size. Usually ranging from 18 to 22 millimeters, but specimens as small as 14 millimeters and others as large as 28 are taken occasionally, especially females if measurement is taken to the tip of the oviduct.

The body usually is more hairy than in other species of its group. Mystax composed of black bristles and gray hairs, dorsum of the thorax with numerous black hairs and bristles on the posterior part, scutellum with an apical row from six to ten black bristles, wings slightly tinged with brownish, legs black with bases of tibia rather dark brown, abdomen black with a narrow gray posterior border to each segment. The male has from two to four apical abdominal segments silvery. Figure 17 shows the form of hypopygium from lateral view. The oviduct is slender, nearly as long as the last four abdominal segments and usually turned to one side or the other in dry specimens. Figure 4.

Habitat: Widely distributed over north-eastern North America, ranging to Florida, New Mexico and Wyoming. A very abundant species over much of its range.

The rather pronounced hairiness of the body, especially the posterior part of the dorsum of the thorax where the hairs are unusually long and plentiful, the row of bristles on the scutellum, the brown and not yellow tibiæ and form of hypopygium rather easily distinguishes this species from others of its group.

Variation in size and the extent of the silvery color of the male abdomen has given an excuse for a number of synonyms of the species. Thus macrolabis is used for the specimens having four segments silvery. I have observed this character often and find it appearing so irregularly that it can hardly be

considered specific. Wiedemann's *niger* appears to be a rather large female of *aestuans*. Some Georgia specimens before me measure 26 millimeters and agree with the description of *niger*.

Erax apicalis Wiedemann.

Size variable. Males and females before me are from 14 to 22 millimeters in total length; average specimens are about 17 millimeters long. Mystax white with only a few black bristles above, beard silky white. Dorsum of the thorax with very short black pile anteriorly and a sparse arrangement of longer white hairs and black bristles posteriorly, scutellum with rather long white hair on its disc and two black bristles on its apical margin. Wings hyaline, slightly infurcated near the apex. Femora, tarsi and apexes of tibiæ black, remainder of tibiæ bright yellow. Abdomen gray pollinose with a large quadrate black spot on the dorsum of each segment. Male with the last two abdominal segments silvery but often the anterior one of the two is more or less encroached upon by a black spot. Female with oviduct shining black and near the length of the last four abdominal segments. Lateral view of the hypopygium shown in Figure 18.

The species is southern in range. Specimens from Decatur County, Georgia, collected by Bradley, and from southern Pines, North Carolina, by Manee.

The trim appearance of the species is notable. The hairs of all parts of the body are shorter and sparser than in *æstuans*; normally there are only two black bristles at the apex of the scutellum, although some variation may be encountered, and the tibiæ are bright yellow instead of brown.

Wiedemann ascribes the species to North America, but it is presumed his specimen was from the southern part of the country for other species described near it are from Savannah, Georgia. Prof. Comstock is the only recent writer to mention the observation of sepcimens when he records their preying upon larvæ of *Aletia argillocea* in Alabama.

Macquart described *vicinus* from Galveston, Texas, and the description suggests that it is the same as *apicalis*.

Erax loewii Bellardi.

Total length 19 millimeters. Mystax black and pale intermixed; beard gray with just a tinge of yellowish, palpi with black hair. Thorax largely gray pollinose with the usual black markings, wings nearly hyaline basally, apical half yellowish, male costa a little dilated, stump of the anterior branch of the third vein short. Legs entirely black, posterior of tibia and tarsal segments golden pilose. Male abdomen

dark, segment six on posterior corners and hind margin and segment seven silvery above; genitalia black, regular, with a small rounded prominence apically. Figure 20.

Female colored like the male, stump of the anterior branch of the third vein rather long, longer than the basal section, genitalia somewhat longer than abdominal segments five, six and seven..

Specimens from Mexico, Tapachula, Chiapas, Cordoba, Morales, Guatemala, and from Onaca, Columbia.

There are only a few species of *Erax* with entirely black legs, so this one is rather easily identified. Williston's clear description of *dolichogaster* lends a feeling of satisfaction to the student who has it for determination and Bellardi's figure of lœwii is very good. That the two names refer to the same species is quite evident. Neither Williston or Osten Sacken recognized *lœwii* in Biologia Centrali Americana.

Erax tabescens Banks n. sp.

Male. Total length 18 millimeters. Similar to Erax aestuans in having the hind part of third vein ending beyond wing tip, and the fork beyond the base of the second posterior cell. The mystax is black, with some white hairs, palpi black haired, head and thorax also with black hairs. The venter is gray with dark median streaks, the sides and hind margins of the segments above pale, the lateral margin of the sixth segment broadly silvery, the seventh wholly silvery. The abdomen is more slender than in Erax aestuans. The hypopygium is rather smaller, but noticeably more slender than in Erax aestauns and is clothed with black hairs; the legs are black, the tibia, except tip, pale yellowish, the hair of femora and tibiæ is almost wholly white (mostly black in Erax aestuans). See Figures 16 and 26.

From Florida (Loew collection and his manuscript name.)

It appears that only one species of the genus *Erax* outside of the *æstuans* group has been reported from the West Indies. Both Bigot and Williston report *rufibarbis* from Cuba, but it seems that this species is only occasionally taken. The species of these islands are much alike in general appearance and some of them are confused with others in literature, although not much has been written aside from the original descriptions.

What is known now as *æstuans* Linne has a large number of synonyms as may be seen by reference to the list of species on a previous page, and besides it has been customary to identify related species with this one because of the close relationship of members in the group. Study of much material from various parts of the country seems to throw some doubt on the cor-

rectness of the extensive distribution of *æstuans* which is given as occurring from New England to Guiana, including records for the West Indies.

Seven species are recognized in the material at hand from the West Indies, mainly based on a study of male genitalia, and none of them are regarded as the common *æstuans* Linne of the Eastern United States. The following key will aid in separating them.

1. Mystax pale, scutellum with white pile and bristles 2
   Mystax in large part black, scutellum with black bristles 4
2. Mystax straw yellow . . . . **nigritarsis** n. sp.
   Mystax white 3
3. Hypopygium long and narrow . . . . **portoricensis** n. sp.
   Hypopygium short and tumid . . . . **rufitibia** Macq.
4. Male costa distinctly thickened and dilated beyond the tip of the auxiliary vein, wings distinctly reddish 5
   Male costa not thickened and dilated, wings nearly hyaline 6
5. Hypopygium much enlarged, rather large robust species . . . . **stylatus** Fabr.
   Hypopygium small, species 16 millimeters in total length **nigrimystaceus** Macq.
6. Hypopygium short and tumid, shining black all over . . . . **rufitibia** Macq.
   Hypopygium elongate 7
7. Large species, hypopygium much elongate . . . . **fulvibarbis** Macq.
   Medium sized species, hypopygium only slightly elongate . . . . **haloesus** W. K.

Erax stylatus Fabricius.

Total length, male 20 to 26 millimeters, female, 18 to 28 millimeters. Mystax composed of numerous black bristles intermixed with fine white hair, beard white, palpi with white hairs, but mixed in is an occasional black one, in some specimens more than others. Femora entirely black, tibiæ yellow, each very narrowly black at apex, tibiæ somewhat darker than the tibiæ and with numerous black bristles; wings distinctly brown.

Male genitalia large, fully as long as abdominal segments five, six and seven. See Figure 32. Costal border of the wing distinctly dilated beyond the tip of the auxiliary vein. Usually no stump on anterior branch of the third vein, although in some cases there is a very short one.

Female genitalia shining black, about as long as segments four to seven, wings almost hyaline, costal border of wing not dilated, anterior branch of the third vein with a distinct stump.

Specimens from several places in Cuba, from Porto Rico, and one male from extreme southern Florida, indicating a wide range. The Florida specimen is peculiar in having the whole abdomen from the apex of the second segment to the genitalia silvery, but I can find no other differences.

Although *stylatus* has not been recognized by most authors, Wiedmann's figure should help in its determination. With more

than thirty very well preserved specimens for study the literature has been consulted fully and the above synonymy worked out. I have no doubt the males and females before me are the sexes of the same species. They seem to combine with characters mentioned by Fabricius, Macquart and Walker who, as a usual thing, seem to have had each a single specimen in hand. Thus the descriptions of *stylatus* and *invarius* were taken from females, while those of *caudex* and *haitensis* were of males. The name *caudex*, as Walker indicates, was used because of the "very large" genitalia. Macquart's figure of the wing of *haitensis* shows the distinctly dilated costal border which is shown in the males before me. The large size Walker gives for *invarious*, together with other characters, is good proof of its synonymy with *stylatus*. These statements are emphasized when it is pointed out that among no less than eight West Indian species this is the only one that combines the dilated costa and large male genitalia, while only one other has a slightly dilated costa and one a somewhat enlarged hypopygium. Most likely Van der Wulp was in error when he reported *stylatus* from Wisconsin. The descriptions given by all the author's mentioned in this connection are more or less deficient and one could easily apply them to several species of the genus.

Erax rufitibia Macquart.

Total length 18 millimeters. Rather dark species, thorax and abdomen largely gray pollinose. Mystax black with a few white hairs intermixed, beard white, palpi black haired, hairs and bristles of the thorax all black; wing slightly fumose, no costal dilation in the male, anterior branch of the third vein with a stump which is about equal in length to the basal section. Femora black, tibiæ and tarsi almost wholly red. Sixth and seventh abdominal segments silvery in the male, genitalia of male short, somewhat tumid. Figure 30.

Females agrees with the male except in sexual characteristics.

From Bahamas and Cuba.

Erax portoricensis n. sp.

Total length 20 millimeters. Mystax, hairs of the palpi and beard white, an occasional black hair in the mystax, dorsum of the thorax largely rusty brown pollinose, wings pale brown, nearly hyaline, costal margin not dilated, stump of the anterior branch of the third vein equal in length to the basal section, femora and tips of tibiæ black, basal three-fourths of tibiæ yellowish brown, tarsi dark reddish brown, nearly black, with abundance of black bristles. Abdomen darker

dorsally, segments six and seven silvery. Male genitalia elongate, rather narrow, apical part narrowed, then rather suddenly widened, angular at apex. See Figure 24.

Female colored like the male, but tibiæ more plainly reddish brown, genitalia hardly as long as segments four to seven inclusive.

Type: Male from Ensenada, Porto Rico, June 14 to 19, 1915, and allotype from the same place at the same date, property of American Museum of Natural History.

The male is easily recognized by its peculiar genitalia.

Erax nigritarsis n. sp.

Total length 18 millimeters. Mystax, beard and hairs of the palpi all light colored. Thorax in large part gray pollinose, mid-dorsal space and some spots on either side of mesothorax black on account of the very sparse pollen with which they are covered. Wing hyaline, only a tinge of yellowish, costal border only very slightly dilated, so slight that it is hardly evident, stump of the anterior branch of the third vein very short, much shorter than the basal section; femora black, tibiæ yellow to near the apex, tips of tibiæ and tarsi intensely black, ventral side of metatarsal segments and some other segments golden pilose. Abdomen gray pollinose, darkest dorsally, segments six and seven silvery, genitalia short, somewhat tumid from side view, narrowed from the middle towards apex where it is truncate. See Figure 29.

Female colored like the male in all respects, genitalia shining black, approximately as long as abdominal segments four to seven inclusive.

Type: Male and allotype from Holguin, Cuba, December 19, 1904, collected by H. S. Parish. In the author's collection, a male and four females from various Cuban localities in American Museum of Natural History.

The pale mystax, tibial hairs, beard and black tarsi, with the structural characters described are distinctive for the species.

Erax fulvibarbis Macquart.

Total length 25 millimeters. A dark appearing species. Much of the thorax and parts of the head and abdomen rusty brown pollinose; mystax composed of numerous black bristles with a tuft of rather coarse white hairs below, beard white, palpi black haired; femora all black, each femur, especially the posterior, has a longitudinal row of six or seven rather strong black bristles on the outer side, beginning well towards the base and extending to near the apex. Most species have not more than four of these bristles. Tibiæ light brown with the apex of each distinctly black, tibiæ black; wings tinged with brownish, front costal border not dilated in the least, anterior branch of the third vein with a very short stump. Abdomen dark, segments two and three each, with a silvery triangular marking on each side posteriorly, segments six and seven silvery dorsally, lateral view of male genitalia shown in Figure 23.

A male specimen from San Domingo. This species agrees exceedingly well with Macquart's description of *fulvibarbis* and comes from the type locality. The row of six or more bristles on outside of hind femur easily suggests the species.

Erax haloesus Walker.

Total length 18 millimeters. Mystax white with numerous heavy black bristles, beard white, scutellum with white hairs on its disc and about four rather slender black bristles on its margin; tibiæ bright reddish yellow, except distally, tips of tibiæ and tarsi black, although the latter may be partly dark reddish brown, costa not thickened, wings dilute yellowish hyaline. See Figure 36. Hypopygium elongate, distinctly red at tip.

A male specimen from Jamaica furnished by C. W. Johnson by whom it was identified. The hypopygium enables this species to be determined readily.

Erax nigrimystaceus Macquart.

Total length 17 millimeters. Mystax largely black with pale yellowish hairs intermixed, palpi with black hairs, beard straw yellow, thorax dark, gray pollinose, bristles and hairs black, many black upright hairs on the scutellum, wings distinctly yellowish, a little more intensely so toward apex, costal border plainly, though not strikingly, dilated, stump of the anterior branch of the third vein very short, not half the length of the connecting vein; entire femora, apexes of tibiæ and tarsi clear black, basal three-fourths or more of tibiæ brown. Abdomen dark, partially gray pollinose, segments six and seven silvery. Hypopygium black, not tumid, gradually widened from the base to beyond middle then slightly narrowed and truncate at apex with two minute emarginations, one dorsal and the other ventral. See Figure 31.

Male from Dominica, West Indies, November, 1903. Furnished by Chas. W. Johnson.

The **carinatus** Group.

In Western United States and extending into Mexico and Central America there are several species of the genus *Erax* that are distinct from the others on account of the following characters:

The dorsum of the mesothorax is more convex than usual, with a distinct crest of erect hairs on the middle of the dorsum, beginning just behind the head and extending back to beyond half the distance to the scutellum. Branching of the third vein beyond the base of the second posterior cell; stump rudimentary or altogether absent in the male, present and somewhat variable in length in the female; costa in the male always thickened and expanded but much more evident in some

species than others. Ten species of this group are at hand and at least one other is characterized sufficiently so that it should be determined easily when specimens are procured.

1. Vestiture of the scutellum, aside from the black marginal bristles, black or yellow.......2
   Vestiture of the scutellum, aside from the black marginal bristles, white....4
2. Vestiture of the scutellum black.......**jubatus** Williston
   Vestiture of the scutellum composed of black bristles on the margin and yellow hair on the disc.......3
3. Male with the last four abdominal segments silvery.....**concinnatus** Williston
   Male with the last two abdominal segments silvery.......**carinatus** Bellardi
4. Femora red apically and sometimes posteriorly.......5
   Femora all black.......6
. Second to fifth abdominal segments of the male with long white hair parted at the middle and directed outward, abdomen wholly gray pollinose. **unicolor** Bellardi
   Abdomen without hair parted at the middle and directed outward, basal segments of the abdomen black.......**parvulus** Bellardi
6. Robust species, mane-like crest of the anterior part of the mesothorax, especially thick and long, male costa very prominently thickened, **subcupreus** Schaeffer
   Slender species, mane-like crest normal, male costa only slightly thickened...7
7. Male abdomen with only the last two or three segments entirely silvery, without prominent white hair parted at the middle and directed outward; other segments with black markings.......**latrunculus** Williston
   Male abdomen with at least four or five segments silvery, and with long white hair parted at the middle and directed outward.......8
8. Hypopygium divided apically with both parts of nearly equal length. **cressoni** n. sp.
   Hypopygium emarginate apically with the upper part much shorter than the lower.......**costalis** Williston

Erax carinatus Bellardi.

Total length 18 millimeters. Body yellowish gray pollinose, hairs and bristles black and pale yellow. Mystax yellow with a few black bristles, beard paler yellow than the mystax, ocellar bristles black, hair on scutellum and in front of it straw yellow, a few black bristles on the scutellar margin; femora black, tibiæ and tarsi largely red, bristles black. Abdomen with short, sparse, yellowish hair, segments six and seven silvery. See Figure 58.

Male from Guerrero, Mexico.

Erax concinnatus Williston.

Total length 16 millimeters. Mystax and beard pale yellow, the former mixed with black bristles, palpi black haired. Disc of scutellum and rear of mesothorax yellow haired, margin of scutellum with a few black bristles. Femora entirely black, tibiæ and tarsi yellow, apex of tibia and each tarsus darker. Wings yellowish hyaline. Abdominal segment one and two and base of three black dorsally, sides of first three segments, apex of three and all of four to seven inclusive, silvery, hypopygium black, of medium size. See Figure 57.

Male from Guerrero, Mexico.

Erax parvulus Bellardi.

Total length 13 to 15 millimeters. Mystax and beard white, the former with black bristles intermixed. Disc of scutellum and rear of mesothorax white haired. Margin of scutellum with a few black bristles. Wings hyaline. Femora, except at extreme apex, black, apexes of femora, tibia and tarsi red. Male, first three abdominal segments dorsally black, narrow posterior margins of two and three and all of four, five, six and seven silvery. Hypopygium black. See Figure 55. Female abdomen black, narrow sides and hind margin of each segment gray pollinose, oviduct slightly longer than the last three abdominal segments.

Male and female from Guerrero, Mexico.

Erax unicolor Bellardi.

Total length 16 to 19 millimeters. Mystax pale yellow with a few black bristles, beard pale yellow, palpi black haired, mesothorax with black hairs and bristles, scutellum with white hairs and a few black bristles on its margin, femora black to near the tips, apexes of femora and tibiæ and tarsi red. Abdominal segment one and base of two gray, apex of two, and whole of segments three to seven, inclusive, silvery; segments two, three, four and five with long white hair parted at the middle and directed outward. Hypopygium black, emarginate at the tip. See Figure 60.

Female colored much as in the male, abdominal segments two to seven each with a dark triangle dorsally, oviduct about as long as the last three abdominal segments.

A male and female from Amatitlan, Guatemala, and five males and females from Tehauntepec, Mexico, (Sumichrast).

Erax latrunculus Williston.

Total length 15 to 18 millimeters. Mystax white with a very few black bristles, beard white, rear of the mesothorax and disc of the scutellum with white hair, margin of the scutellum with several black bristles, femora all black, tibiæ and tarsi red. Male, abdominal segments one to five each with a black spot above, large on segments two, three and four, small on five. Sides and hind margin of two to five inclusive and all of six and seven silvery. In one specimen six is all silvery, lacking the dorsal black spot. Hypopygium shining black, mostly with pale hairs. See Figure 56.

Female, abdominal segments one to seven inclusive each with a black spot above, sides and hind margin of each segment densely gray pollinose. Oviduct somewhat shorter than the last three abdominal segments combined.

Male and female from Arizona. This description is taken from specimens from Cornell University. Professor Bradley

considers them as belonging to the material which Williston had when he wrote the original description although they are not marked as types.

Erax jubatus Williston.

Total length 18 to 23 millimeters. A large, black, robust species, plainly the largest of the group. Mystax composed of numerous long bristly hairs which are mixed white and black in about equal numbers, beard silky white, palpi black haired, hairs and bristles of the thorax largely black, numerous long black bristly hairs on the scutellum and in front of it, although in some specimens white ones are intermixed. Femora black, tibiæ and tarsi dark red. Abdomen largely black, narrow posterior margin of the segments gray. Male, abdominal segments six and seven silvery, hypopygium noticeably large. See Figures 3 and 54. Costal margin of the wing prominently expanded and there may be a very short stump on the anterior branch of the third vein.

Female, usually a distinct stump on the anterior branch of the third vein; oviduct somewhat longer than the last three abdominal segments.

Forty specimens of both sexes from Northern Mexico, Arizona, New Mexico and Colorado.

A study of the variations exhibited in the specimens at hand suggest strongly that *prolificus* Osten Sacken, is a synonym of *jubatus*. The type locality for *jubatus* is New Mexico and that of *prolificus* is Northern Sonora, Mexico. Specimens vary much in some particulars, many have white hairs on the scutellum and before it, the bristles of the body are mostly black, but yellow and brownish ones occur, the fifth abdominal segment of the male is almost wholly black, with a rounded black spot, or entirely silvery.

The large size, generally dark color, and enlarged hypopygium suggest the species. However, there is much difference between the largest and smallest specimens.

Erax subcupreus Schaeffer.

Total length, male and female, 15 to 20 millimeters. Larger and more robust than costalis. Mystax rather long and dense, composed of black and white bristles and hairs in nearly equal proportion. Mane-like crest of hairs on the middle of the dorsum of the thorax conspicuous, black and reaching well beyond the transverse suture where it merges into a widened area of black and white hairs and bristles which reaches to the scutellum. Scutellum densely white haired and with several black marginal bristles, wings hyaline, femora black, tibiæ and tarsi very dark reddish. Male abdomen quite densely haired, first five or

six segments with long white hair parted at the middle and directed outward. Hypopygium black with black hair. See Figure 52.

Female abdominal segments all black above, sides and narrow hind margin of each gray pollinose, oviduct about as long as the last four abdominal segments. Fresh specimens have the body more or less metallic, which accounts for Schaeffer's name.

Specimens from Montana, Colorado, New Mexico, Arizona and Nevada.

The robust form and white-haired scutellum are characteristic for the species.

Erax cressoni n. sp.

Male. Total length 14 millimeters. Mystax and beard white, palpi black haired, mane-like row of hairs on the middle of the mesothoracic dorsum black and composed of numerous short hairs and an occasional long one, space in front of the scutellum with scattered black bristles and short white hairs. Scutellum with numerous short white hairs on the disc and four long dark bristles on the margin; femora black, tibiæ and tarsi red; wings hyaline, branching of the third vein far beyond the base of the second posterior cell, anterior branch with scarcely a suggestion of a stump. Abdomen, first segment white haired, second to fifth segments with white hair parted at the middle and directed outward, hair shorter on the fifth segment than on the others, first segment, anterior part of second and a small triangle anteriorly on dorsum of third showing dark from above, otherwise abdominal segments silvery white. Hypopygium dark, pale hairy, superior part notched at apex, part above notch narrow, but of same length as part below. See Figure 50.

Female. Length 14 millimeters, like the male in most respects; anterior branch of the third vein with a stump about equal in length to the basal section, each abdominal segment with a triangular spot which is not as densely pollinose as the other parts, oviduct shining black, about as long as the last three abdominal segments.

Type: Male and allotype from Alamogordo, New Mexico, in the collection of the Academy of Natural Sciences of Philadelphia; other specimens from El Paso, Texas.

Named for E. T. Cresson, Jr., who sent me the specimens.

Erax costalis Williston.

Total length, male and female, 14 to 16 millimeters. Mystax white with some black bristles intermixed, scutellum with abundance of white hair and about four black marginal bristles, wings hyaline, femora black, tibiæ and tarsi mostly dark red. Male, abdomen with segments two, three and four with long white hair parted at the middle and directed outward, first three segments largely black dorsally, apex of three and all of segments four to seven inclusive silvery, hypo-

pygium black with white hair. See Figure 53. Female, abdomen with each segment marked with black dorsally, sides and posterior margin of each segment white pollinose, oviduct somewhat longer than the last three abdominal segments.

Specimens from Montana, Wyoming and Colorado.

There is some doubt as to the proper identification of *costalis*, but the information available indicates that this species is the one for which Williston used the name in his key, Trans. Am. Ent. Soc., XII, 64. No description was ever wtriten, and Aldrich did not give it in his catalogue.

The **tuberculatus** Group.

The males of this group are at once known by the presence of a tooth-like prominence on the venter of each of abdominal segments four, five and six, and costa entirely normal. Branching of the third vein distinctly beyond the base of the second posterior cell. The species are slender and of rather small size.

1. Hypopygium and ventral tooth-like process of the abdomen red, **spiniventris** n. sp.
   Hypopygium and ventral tooth-like processes black........ 2
2. Ventral tooth-like processes of the abdomen all acute at apex, **tuberculatus** Coquillett
   First two ventral tooth-like processes knobbed at the apex.. .**productus** n. sp.

Erax tuberculatus Coquillett.

Total length 15 to 17 millimeters. Body gray pollinose and white hairy, ocellar bristles and some bristles in lower part of mystax black, palpi black hairy; femora, apices of tibia and tarsi black, tibia otherwise red. Male with venter of abdominal segments four, five and six each with an acute, black, tooth-like process produced downward. The presence of these ventral spines will put the male into its group at once, wings hyaline, branching of the third vein distinctly beyond the base of the second posterior cell, stump usually shorter than the basal section.

There is no very good way to characterize the females, but the small size and the forking of the third vein distinctly beyond the base of the second posterior cell are suggestive of the group. The oviduct is only slightly longer than abdominal segments six and seven in tuberculatus, but longer in other species of its group.

The type is in the United States National Museum. Other specimens from Davis Mountains, Texas (F. M. Gaige), and from West Fork, Texas (J. E. Scherer), taken in June.

Erax spiniventris n. sp.

Male. Total length 12 millimeters. Vestiture of the body largely white, ocellar bristles black, bristles of the legs largely white, but now and then a black one is intermixed; tibiæ, except the extreme apex of

each red, otherwise legs black, wings hyaline, branching of the third vein beyond the base of the second posterior cell, stump very short. Abdomen largely gray pollinose, venter of segment four and five each with a distinct red prominence, narrowed basally and enlarged apically, with the main part of the enlargement directed posteriorly; sixth segment with a narrow pronounced red tooth-like appendage pointing almost directly downward and acute at apex. Hypopygium red in color, from side view, widest at basal third and gradually narrowed toward apex, where it is almost truncate.

Type: Male from Santa Rita Mountains, Arizona, 5,000 to 8,000 feet, July, (F. H. Snow). In the author's collection.

The form and color of the hypopygium and ventral abdominal prominences easily characterize the male of the species.

Erax productus n. sp.

Male. Total length 16 millimeters. Body largely white pilose and gray pollinose, palpi black hairy, basal two-thirds of tibiæ red, legs otherwise black, and with black bristles; wings pale yellowish, hyaline, branching of the third vein beyond the base of the second posterior cell, stump very short. Abdominal segments four and five ventrally, each with a short blunt prominence, segment six with a large acute prominence directed downward. Hypopygium, from side view, of nearly uniform width, rather long, apically each outer corner prominently produced.

Female. Of similar size and color as the male; oviduct fully as long as the last three abdominal segments.

Type: Male and allotype from Flinn Springs, Lakeside, Cal., August 9, 1917. E. G. Holt, collector. Collection of the author. Other specimens from Spring Valley and Poway, August 10 and 14, by the same collector.

This species is of nearly the same size as *tuberculatus*, but the ventral abdominal appendages and hypopygium are quite different and easily characterize the male.

The **rufibarbis** Group.

The females of this group differ from all other species by having the last segment of the oviduct divided at the tip. This character is easily seen from dorsal view. The mesothorax and scutellum is unusually bristly, the third vein branches beyond the middle of the distance between the base of the second posterior cell and the small cross vein. The male has abdominal segments six and seven silvery. The oviduct is rather short and rigid and the hypopygium is rather small. Mystax without or with very few black bristles.

1. Mystax yellow, body and wings dark colored............**rufibarbis** Macquart
   Mystax nearly white, body gray pollinose, wings hyaline....**bicaudatus** n. sp.

Erax rufibarbis Macquart.

Male. Total length 16 to 30 millimeters. Mystax and beard distinct reddish yellow, palpi black and clothed with black hair, color of the body dark brown pollinose, thorax with black hair and bristles, scutellum with black hairs on the disc and numerous black bristles, irregularly arranged, on the margin. Legs mostly black with numerous dark and reddish hairs and black bristles, tibia dark reddish on basal half or more, wings brown, many specimens have the margins of the veins more intensely colored, costa not dilated, branching of the third vein nearly opposite the base of the second posterior cell. Abdominal segments six and seven silvery, hypopygium shining black.

Female colored like the male and just as variable in size; oviduct shining black, about as long as abdominal segments six and seven, abruptly narrowed before the apex, furcate from dorsal view.

The species has a wide range in Eastern North America, including the West Indies. Normally colored specimens are at hand from as far west as the Dakotas and central Texas. Farther west specimens are lighter in color and indications are that *rufibarbis* more or less gradually approaches *bicaudatus* in that region.

A study of venation in *Erax* reveals some variations which are useful in grouping species. There is a small group of species that has three submarginal cells normally and there are some species outside this group where now and then a specimen has three submarginal cells in only one or in both wings. Thus *anomalus*, *candidus* and *pernicis* may be characterized as a group by the presence of the extra cell while *rufibarbis* and *bicaudatus* have an occasional specimen only with this character. An estimate of material at hand indicates that about two per cent of these species are abnormal in this respect. The type of *ravus* in the U. S. National Museum is an abnormal *rufibarbis* and from much material studied, results indicate that scarcely any doubt exists that *completus* is the same, thus adding two more to the long list of synonyms of our common *Erax*.

Macquart's figure of the wing of his *completus* shows the forking on the third vein opposite the cross-vein at the base of the second posterior cell, and not midway between the latter cross-vein, and the small cross-vein as is the case in all the species of *Erax* having three submarginal cells normally. This fact and his statement regarding the male "*Abdomine segmentis duobus apicalibus niveis*," which is distinctly so in regard to *rufibarbis* but not of any of the anomalus group, are the con-

vincing facts in support of the conclusion reached in regard to *completus.*

There is some doubt about *Asilus dascyllus* of Walker but some things in the description suggests *rufibarbis* and the great amount of collecting in Massachusetts, the type locality, up to the present has not revealed any other possibilities, so have used my best judgment. Walker himself transferred *dascyllus* to *Erax* later when he had a better understanding of the genus.

Van der Wulp's figure of the female of his *Proctocanthus virginianus* is an excellent outline of *Erax rufibarbis.* The tip of the oviduct is quite suggestive and it is not right for *Proctacanthus* at all. The size is right and the description is not bad.

Erax bicaudatus n. sp.

Male. Total length 24 millimeters. Mystax and beard white, palpi black with black hair. Thorax largely with white hairs and bristles. Mid-dorsum before the suture with a row of rather long black hairs, which is suggestive of the mane in the jubatus group, although quite different, for it is made up of numerous hairs somewhat sparsely placed over a rather wide strip and does not form a dense comb as in the group mentioned. Well preserved specimens show it to best advantage. Scutellum with black hair on the disc and numerous white bristles placed irregularly on the margin. Wings hyaline, costa not dilated, branching of third vein a little before the base of the second posterior cell, stump of the anterior branch somewhat longer than the basal section. Legs largely black with numerous white hairs and black bristles, tibia reddish on basal third, especially the anterior and middle pairs. Abdomen dark, partly gray pollinose with much white hair and dorsally with some short black hair, segments six and seven silvery. Hypopygium medium sized, black, reddish in part, clothed mostly with white hair.

Female. Total length 25 millimeters. Colored like the male and differing only in sexual characters, oviduct about as long as abdominal segments six and seven, viewed from side narrowed abruptly before apex with a backward projecting point which from dorsal view is seen to be furcate.

Male type from Montclair, Colorado, July 30, 1898, and allotype from Morrison, Colorado, May 20, 1898. Both localities are near Denver.

Numerous other specimens of both sexes from a wide range, varying in size from 17 to 31 millimeters, and slightly in color, some specimens appearing much blacker than others.

The structure of the oviduct will separate the female from all species of its genus except *rufibarbis*, of which *bicaudatus*

appears to be the western representative. Over much of its range the species is very differently colored from *rufibarbis*, but the two approach each other in some localities. An occasional specimen has three submarginal cells either in one or both wings. The furcation of the third vein averages slightly further forward in *bicaudatus* than in *rufibarbis*, but this is variable within limits in both species. Specimens have been sent in under no less than half a dozen different specific names.

The **stramineus** Group.

One of the largest groups of the genus *Erax* is characterized by having the furcation of the third vein distinctly anterior to the base of the second posterior cell. In most all the species the mesothorax has many bristles posteriorly and the scutellum has many bristles on its margin and often numerous long hairs on its disc. Practically all the species are western or southern in distribution.

1. Furcation of the third vein at or before the middle of the distance between the base of the second posterior cell and the small cross vein...............2
   Furcation of the third vein distinctly beyond the middle of the distance between the base of the second posterior cell and the small cross-vein....18
2. Male abdomen without long hair parted at middle and directed outward on one or more segments.......................................3
   Male abdomen with long hair parted at the middle and directed outward on one or more segments.......................................5
3. Hypopygium from side view plainly divided at tip, oviduct conical, **interruptus** Macquart
   Hypopygium from side view not divided...............................4
4. Hypopygium from side view narrowest at apex, tibiae basally bright reddish yellow.............................**texanus** Banks, n. sp.
   Hypopygium from side view not narrowed at apex, tibiae basally dark reddish brown.............................**californicus** Shaeffer
5. Mystax yellow...6
   Mystax not yellow..11
6. Tibiae at least largely red..7
   Legs black...9
7. Male third abdominal segment only with long white hair parted at the middle and directed outward..................**aurivestitus** n. sp.
   Male abdomen with at least four segments with long white hair parted at the middle and directed outward..............................8
8. Abdomen white haired to base. Hypopygium with a rather conspicuous tuft of hair inferiorly at apex..........................**canus** Hine
   Abdomen, especially the male, conspicuously darker on first and second segments than on the following ones, no tuft of hairs at apex of Hypopygium, **dubius** Williston
9. Body conspicuously dark colored, male with abdominal segments four, five and six only, white haired..........................**splendens** Williston
   Body largely yellowish gray pollinose, male with abdominal segments three to seven inclusive white haired..............................10
10. Usually not to exceed 18 millimeters in total length.....**stramineus** Willis.
    Specimens 20 millimeters or over in length..............**rapax** Osten Sacken
11. Mystax composed of black and white bristles and hairs intermixed........12
    Mystax wholly pale...13

12. Hypopygium from dorsal view conspicuously widened at apex. . **inflatus** Hine
Hypopygium not widened. . . . . **eximius** Bellardi
13. Bristles and hair of body and legs largely pale. Hypopygium from dorsal view distinctly widened at apex. . . . . **varipes** Williston
Bristles of the legs largely black. Hypopygium not widened apically. 14
14. Hypopygium with a rather conspicuous tuft of hair below at apex, furcation of the third vein very near the middle of the distance between base of second posterior cell and small cross vein. . . . . **canus** Hine
Hypopygium without conspicuous tuft of hair apically, furcation of the third vein plainly before the middle of the distance between the base of the second posterior cell and the small cross-vein. 15
15. Hypopygium plainly notched on apical border. 16
Hypopygium not notched on apical border. 17
16. Thorax yellowish pollinose, first two segments of male abdomen colored like the thorax. . . . . **argentifrons** Hine
Thorax gray pollinose, first two male abdominal segments colored like the following ones. . . . . **argyrosoma** Hine
17. Hypopygium truncate at apex. . . . . **truncatus** Hine
Hypopygium rounded at apex. . . . . **pallidulus** Hine
18. Femora largely red, especially posteriorly. 19
Femora entirely black 20
19. Male abdominal segments two, three and four with black markings, **argyrogaster** Macquart
Male abdominal segments two, three, four, five and six with black markings, **triton** Osten Sacken
20. Mystax white, scutellum with long white hair and bristles. 21
Mystax yellow, scutellum with yellow or black hair and bristles. 22
21. Very small species, 12 millimeters, mesothorax posteriorly white haired, **pilosus** n. sp.
Larger species, not under 15 millimeters, mesonotum posteriorly black haired. . . . . **coquillettii** n. sp.
22. Mystax bright yellow, scutellum with long yellow hair and bristles, **auripilus** Hine
Mystax pale yellow, scutellum with black hair and bristles. 23
23. Male, first three abdominal segments without silvery markings, female uniformly yellow pollinose. . . . . **plenus** Hine
Male, only first two abdominal segments without silvery markings; female, abdomen with a series of large black markings dorsally, one to each segment. . . . . **nemoralis** Hine

Erax stramineus Williston.

Total length 15 to 18 millimeters. Mystax, beard and hairs of the palpi pale but distinctly yellow, bristles of the front and occipito-orbital bristles sometimes black, but they may be yellow and in most specimens examined at least part of them are pale yellow. Dorsum of the mesothorax with black hairs and bristles in many specimens, but in some the bristles posteriorly, at least are pale; scutellum with a row of many long black or pale bristles on the margin. Wings hyaline, narrow, furcation of the third vein distinctly before the middle of the distance between the anterior cross-vein and the base of the second posterior cell, stump usually near twice as long as the basal section. Legs nearly entirely black in some specimens, tibiæ reddish in others. In many species of the genus the tibiæ normally are widely red basally and narrowly black apically. Here it may be said that the normal color of the legs is uniformly black and the variation toward red appears to be due to the lack of varying amounts of the dark pigment, thus

giving more or less the appearance of a faded condition to the tibiæ and even to the other parts of the legs. Legs with much pale yellow hair and black and some pale bristles. Male. First and second abdominal segments gray pollinose with rather sparse pale hairs, segments three, four and five with prominent white pile parted at the middle and directed outward; segment six similar, but pile much less prominent; segment seven silvery pollinose with short and scattered white hairs. Hypopygium, from dorsal view, rather narrow, sides nearly parallel to apical third then gradually widened; from side view, rather long of nearly the same width throughout and with a prominent extension apically. See Figures 1 and 33. Female, abdomen nearly uniformly gray pollinose, oviduct shining black, somewhat longer than abdominal segments five, six and seven.

Several specimens of both sexes from Montana and Wyoming.

It is quite nearly related to *rapax*, as Osten Sacken stated when he described the latter. The smaller size and the fact that the entire third abdominal segment is silvery seem to distinguish *stramineus*. A quantity of material, including the two species, is at hand from the territory extending from Montana to Guadalajara, Mexico, and I find it difficult to make a satisfactory separation from all localities, but this is easy to do with specimens from the northern and southern limits of the area indicated.

Erax dubius Williston.

There is some doubt of the status of this species, for Williston gave the name in a key in Volume 12, Transaction of the American Entomological Society, page 64, but did not give a description in full. It is reasonably sure, however, that his short diagnosis of *Erax* n. sp., on page 68 of the same paper, refers to *dubius*. A distinct effort has been made to properly identify the species. By correspondence with C. P. Alexander, of the University of Kansas, I find that the specimen which Williston mentions from Washington has been lost, but a specimen from Arizona, very likely that one referred to in the diagnosis, is labelled as the type in the museum at Lawrence. A study of this proves it to be very near *stramineus*, but with black femora and red tibiæ and tarsi. The color of the body is exactly that of *stramineus* and the form of the hypopygium is the same. Williston described *stramineus* as having entirely black legs, but the fact is that in a long series of specimens

variations occur even to the extent of having the tibiæ and tarsi in large measure reddish. It seems best, after considering the facts to regard *dubius* as no more than a variety of *stramineus* if not a synonym.

Several specimens from Wyoming agree with the type specimen of *dubius*.

Erax rapax Osten Sacken.

Total length 20 to 25 millimeters. Mystax, beard and palpal hairs decidedly yellow, frontal and occipito-orbital bristles mostly black. Bristles and hairs of the mesothoracic dorsum largely black, margin of the scutellum with a row of many long bristles which are viarable between black and yellow in different specimens. Wings yellowish hyaline, furcation of the third vein much nearer the small cross than to the base of the second posterior cell, stump distinctly longer than the basal section. Legs black with an abundance of yellow hair, bristles black, but an occasional pale one intermixed. As in stramineus the legs vary in color and many specimens have the bases of the tibiæ reddish while others have the legs generally paler throughout. Male abdomen, segments one, two and anterior part of three dark, nearly black, remainder of three and all of four and five silvery and with silvery hairs parted at the middle and directed outward, six similar but hairs shorter, seven silvery pollinose. Hypopygium black with mostly black pile, although more or less yellow pile is likely to be present. Ventrally this pile is longer and more conspicuous than elsewhere. See Figure 41. Female generally less pilose than the male, abdomen gray pollinose, oviduct shining black, somewhat longer than abdominal segments five, six and seven.

Common in southwestern United States and Mexico. The type locality is Northern Sonora.

This species is difficult to separate from *stramineus* in the northern part of its range.

Erax aurivestitus n. sp.

Male. Total length 22 millimeters. All the vestiture of the head, except the bristles in the region of the ocelli and one or two occipito-orbital bristles on each side, distinctly yellow; head, thorax and base of abdomen yellow pollinose, dorsum of the mesothorax with black hairs and bristles, pleuræ mostly with black hairs and bristles, but with some pale ones intermixed, coxæ with yellow bristles, other parts of legs mostly with abundance of yellow hair and some black bristles, femora black, in ground color, tibiæ and tarsi dark reddish, wings yellowish hyaline, furcation of the third vein distinctly before the middle of the distance between the anterior cross vein and the base of the second posterior cell, stump longer than the basal section. First and second abdominal segments dark in color with mostly dark hairs

both above and beneath; third segment with a peculiar band of long hair, silvery above and darker beneath, extending entirely around it and parted on the mid-dorsum and also on the mid-venter and in each case directed outward; the hairs on the anterior part of the segment are directed somewhat backward and those on the posterior are directed forward to about the same extent; narrow posterior margin of the third segment and segments four to seven inclusive with but very little pile but conspicuously silvery pollinose. Hypopygium black and almost entirely black pilose, but with a little yellow pile basally and also apically; black pile especially long and prominent on sides and venter; dorsally of nearly uniform width, but wider and shorter than in sagax; from side view a very prominent extension at apex. Figure 42.

Male type from Morelos, Mexico, collected by D. C. Crawford, in the author's collection.

The peculiar third abdominal segment and the hypopygium characterize this species.

Erax splendens Williston.

Total length 22 to 25 millimeters. Mystax and beard bright yellow, hair and bristles of the front and the occipito-orbital bristles black, thorax rather sparsely brown pollinose and with black hair, wings yellowish, furcation of the third vein not far from the anterior cross vein, stump a little longer than the basal section. Front legs with dense yellow hair anteriorly on coxæ, and ventrally on femora, tibiæ and tarsi, but there is much black hair on the appendages also; middle ahd hind legs mostly black haired, but there is some variation in a series of specimens. Legs entirely shining black in ground color. Male abdomen black with black vestiture, except segments four, five and six, which are silvery. See Figure 39. Female, abdomen dark, segments two to six inclusive yellowish gray pollinose with rather small irregular markings dorsally. Oviduct shining black, hardly as long as the last three abdominal segments.

Several specimens of both sexes from Guadalajara, Mexico, collected by McClendon.

The very dark color of the body of this species with the bright yellow mystax and beard makes its identification easy.

Erax truncatus Hine.

Thorax yellowish-brown, above, abdomen gray, first four segments with long white hairs, legs black with the exception of the basal part of each tibia which is light reddish. Total length 22 to 30 millimeters.

Mystax and beard white, ocellar, occipito-orbital and a transverse row of bristles on the dorsum of the prothorax black, palpi with black and white hairs intermixed, dorsum of the thorax and the scutellum with many black hairs and bristles, but there are some white ones intermixed, wings hyaline.

First segment of the male abdomen with long white hairs on each side, second, third and fourth segments with long silvery hair parted at the middle and directed outward, fifth, sixth and seventh segments silvery white pollinose, but without long hair; hypopygium rather large, from dorsal view about as wide as the last segment of the abdomen, from side view most prominent near middle above and cut off at tip so as to give a truncate appearance. Figure 45.

First seven segments of the female abdomen silvery white; oviduct slender, shining black, about seven millimeters in length.

Several specimens from the Huachuca Mountains, Arizona, July 28, 1907.

The large compact hypopygium of the male and the long oviduct of the female give this species a distinct appearance which makes its separation from others easy.

Erax pallidulus Hine.

A pale colored species with black legs and hyaline wings. The male has the hypopygium small and, from dorsal view, very narrow. Total length 18 to 28 millimeters. Mystax very pale yellowish, beard white, palpi black with white hair, occipito-orbital and ocellar bristles mostly black; thorax dorsally pale yellowish gray with short black hair anteriorly and black and white bristles and hairs posteriorly, scutellum with pale hairs and bristles, legs black, except bases of tibiæ, which are pale, wings hyaline. Male abdomen silver white, first four segments with long white hair, two, three and four with hair parted at the middle and directed outward, five, six and seven without long hair, hypopygium small, black, narrowed toward apex where, from lateral view, it appears nearly evenly rounded. Figure 44.

Female colored like the male. Oviduct black, only slightly longer than the last two abdominal segments.

Three male specimens and a female from Albuquerque, New Mexico, collected by J. R. Watson, and one female from Colorado.

The short hypopygium and oviduct are characteristic of this species.

Erax argyrosoma Hine.

Body nearly uniformly white all over, mid-dorsal stripe of the thorax not plainly marked. Length 23 to 25 millimeters. Mystax and beard white, palpi black with white hair, some of the occipito-orbital bristles black and some white; legs black except the basal parts of the tibiæ, which are yellowish haired, wings hyaline; anterior part of the dorsum of the thorax with short black hair; posterior part and the scutellum with black and white bristles and hairs. First four abdominal segments of the male with long white hair; on two, three and four, this is parted at the middle and directed outward, segments five, six

and seven silver white, but without long hair, hypopygium black with short white hair, somewhat notched at the apex with the lower part extending into a prominence. Figure 40.

Female abdomen gray pollinose, oviduct shining black, four millimeters in length.

Taken by J. R. Watson near Albuquerque, New Mexico. More than a dozen specimens from other localities in New Mexico and western Texas.

Erax auripilus Hine.

A medium sized species characterized by abundance of rather bright yellow hair on all the parts of the body.

Male. Total length 22 millimeters. All the hairs on the various parts of the head yellow, sternum and sides of the thorax with yellow hair, dorsum with black hair, wings clear hyaline, furcation of the third vein distinctly before the base of the second posterior cell and with a long appendage, costa not enlarged near the tip of the auxiliary vein, posterior branch of the third vein meets the costa distinctly before the tip of the wings; legs with yellow hair and black bristles, in most part black in ground color, but the basal half or more of each tibia is bright yellow; abdomen with yellow hair, segments two to five black above with light colored lateral and hind margins, segments six and seven silvery white, hypopygium of medium size, shining black in ground color and clothed with yellow hair. Figure 47.

One male, taken at Clifton, Texas, May 29, 1907, by E. B. Williamson. A male in the collection of the Academy of Natural Sciences was taken at Round Mountain, Texas. Several females in the U. S. National Museum from different localities in Texas.

Erax canus Hine.

Male. Total length 24 millimeters. General body color rather hoary white produced by white pollen and hair, dorsum of the thorax with black hair and bristles, legs with black bristles, mystax and beard pale yellow, bristles of the front black, palpi black with pale yellow hair and bristles, wings hyaline, costa uniform throughout, furcation of the third vein distinctly before the base of the second posterior cell and with a distinct appendage, the posterior branch of the third vein bends forward to meet the costa plainly before the apex of the wings, legs black with the basal third of each tibia reddish; abdomen uniformly hoary white, segments two, three and four on the dorsum with long white hair parted at the middle and directed outward; hypopygium of medium size, black and clothed with white hair. Figure 38.

Female colored like the male, but abdominal segments two, three and four devoid of the peculiar long hair described for the male. Oviduct shining black, slightly longer than abdominal segments six and seven combined.

Male and several females from Claremont, California, sent in by Carl F. Baker; three males in the U. S. National Museum from Los Angeles County, California, Collection Coquillett. The smallest female measures only 17 millimeters in total length.

Erax eximeus Bellardi.

Total length 17 millimeters. Mystax pale with some black bristles intermixed, beard white, palpi black haired, ocellar and occipito-orbital bristles black. Thorax with black hairs and bristles, scutellum with several black, marginal bristles; femora reddish posteriorly and at apex, black anteriorly, tibiæ and tarsi largely red with mostly white hairs and black bristles, wings very slightly smoky hyaline, branching of the third vein midway between the small cross vein and the base of the second posterior cell, stump only very slightly longer than the basal section. Abdomen largely gray, first segment, anterior two-thirds of second and the anterior parts of segments three and four black, posterior part of the second and nearly all of the third and fourth with long hair parted at the middle and directed outward; segments five, six and seven with much shorter hair. Hypopygium dark red, black in places. See Figure 46.

A male specimen from Cuernavaca, Mexico, collected by D. L. Crawford.

This species does not answer in detail to *eximeus*, but goes there in Bellardi's Key. It is the only *Erax* I have with the apexes of the femora red following black.

Erax inflatus Hine.

A dark colored species with the mystax composed of black and gray hairs intermixed, wings hyaline, slightly fumose at apices, legs black with the exception of the extreme bases of the tibiæ which are yellowish red. Length of the males 20 to 25 millimeters; of the females 22 to 26 millimeters.

Front yellowish-gray pollinose, antennæ black, first two segments clothed with gray hair, occipito-orbital bristles and ocellar bristles black, mystax composed of black and gray hairs intermixed, beard silky white, palpi black with black hairs; thorax brownish-gray pollinose with a dark mid-dorsal stripe abbreviated posteriorly, clothed with gray and black hairs and bristles existing in different proportions in different specimens; legs black except the extreme apices of the tibia, which are yellowish-red, furnished with white hairs and black bristles and some golden pile on the underside of some of the segments; wings hyaline, slightly darkened at apex.

Male abdomen with the apex of the second segment and all of the segments from three to seven inclusive silver white, segments two and three with long white hair parted at the middle and directed outward,

four and five shows this arrangement somewhat, but the hairs are short; hypopygium clothed mostly with white hair, enlarged at apical half until it is nearly twice as wide as the seventh abdominal segment.

Female abdomen with each segment white pollinose at sides and apex, otherwise black above, oviduct black, scarcely five millimeters in length, equivalent to the last three abdominal segments.

Twenty specimens received from F. Grinnel, Jr., and taken in Los Angeles County, California. A very distinct species on account of the male hypopygium which appears as if inflated and is nearly twice as wide as the seventh abdominal segment. Males and females from Los Angeles, Kern and San Bernardino counties, California, Coquillet Collection.

Erax nemoralis Hine.

A dark colored species with yellowish mystax and fumose wings. Femora, tarsi and apices of the tibiæ black, bases of tibiæ reddish-brown. Length, male, about 25 millimeters; female, to the tip of the oviduct, 24 to 27 millimeters. Face and front covered with yellowish dust, mystax and beard pale yellow, occipito-orbital and ocellar bristles black, as are most all of the hairs and bristles of the front, palpi black, furnished with many black hairs which often are intermixed with pale yellow ones. Prothorax mostly clothed with pale hairs, remainder of thorax with many black hairs and bristles, but these often are reduced by the presence of greater or less numbers of pale ones; mid-dorsal stripe dark and well marked, abbreviated behind and divided anteriorly, on either side the markings are in the form of ill-defined spots caused by the difference in intensity of the rust-colored dust which gives the thorax its peculiar color; legs black, except the bases of the tibiæ, which are reddish-brown, clothed with black bristles and pale hairs of different lengths, the shorter ones recumbent, some of the segments inwardly, more especially the metatarsi and front tibia, clothed with golden recumbent pile.

In the male abdominal segments one, two and base of three dark, largely clothed with black hair, apex of three and all of four, with the exception of a small black triangle on each anteriorly, white with long white hair parted in the middle and directed outward, five and six silver white with very short hair, remainder of abdomen black, with black hair, however, in some specimens part of seven is whitish and there may be a few pale hairs on the hypopygium. Figure 51.

In the female the segments of the abdomen are gray on the sides and hind margin, otherwise black above, but the latter color is not well defined, especially if viewed with a lense; oviduct about six millimeters in length, equivalent to the last four abdominal segments.

Several specimens of both sexes procured in a brushy woodland at New Roads, Louisiana, July 15, 1905. The specimens were captured while resting near or on the ground.

It is a predaceous insect of possible value on account of its size. Other specimens from Texas and from Falls Church, Virginia.

Erax argentifrons Hine.

Much like rapax. Front white pollinose, mystax white, legs with white hair. Length 18 to 23 millimeters.

Palpi black with white hair, occipito-orbital and ocellar bristles black, antennæ black, first two segments with white hair, beard white. Thorax yellowish-brown with the usual mid-dorsal stripe darker, hairs of sides almost uniformly pale, of dorsum variable between pale yellowish and black; wings hyaline, legs black, except the extreme bases of the tibiæ, which are reddish-yellow, clothed with pale hairs and black bristles. First two segments of the male abdomen colored like the thorax, segments three to seven inclusive silver white, apex of two, all of three and four with long white hair parted at the middle and directed outward, hypopygium much narrower than in stramineus, clothed with black and white hair and distinctly notched at the apex. Figure 35.

Female abdomen uniformly yellowish pollinose and clothed with pale hairs, oviduct about four millimeters in length, equivalent to the last three abdominal segments.

Specimens of both sexes taken in Clark County, Kansas, by Dr. F. H. Snow.

As has been stated, the species has much the appearance of *rapax*, but the somewhat stouter form, the white mystax and beard and much slenderer hypopygium designate it as wholly distinct from that species.

Erax plenus Hine.

A large, robust species, varying in length from 23 to 30 millimeters. Male. Total length 27 millimeters, antennæ black, style nearly twice as long as the third segment, palpi black and clothed with pale yellow hair, face and cheeks with abundance of pale yellowish hairs, ocellar bristles and several bristles on the upper part of the occiput black. Thorax yellow pollinose with most of the hairs and bristles black; wings with a very pale yellowish tinge, costa not thickened near the tip of the auxiliary vein, furcation of the third far before the base of the second posterior cell and with a distinct appendage, posterior branch of the third vein reaches the costa distinctly before the tip of the wing; legs clothed with pale yellowish hairs and black bristles, black, except the tibia which is largely reddish. First three abdominal segments dark, mostly with black hair above and white hair beneath, four white with long white hair parted in the middle and directed outward; five, six and seven white, hypopygium dark in color, short and somewhat tumid. Figure 48.

Female unusually robust for an Erax. Abdomen, except the oviduct, uniformly pale yellowish pollinose, oviduct shining black, about as long as abdominal segments five, six and seven combined. Otherwise colored as in the male.

Several specimens of each sex from Douglas County, Kansas, 900 feet elevation (F. H. Snow). From Onaga, Kansas, and from Osborne County, Kansas, 1557 feet elevation, collected August 3, 1912, (F. X. Williams), Ardmore, Indian Territory, (C. R. Jones); Plano, Texas, (Tucker); Waco, Texas, (Belfrage), and other localities in Texas.

A male from Onaga, Kansas, taken August 20, 1901, is like the other males, except that abdominal segment seven is black instead of silver white. This gives the specimen quite a different appearance, but since similar variations have been observed in other species of the genus it is not considered specific here.

Erax coquillettii n. sp.

Male. Total length 16 millimeters. Mystax and beard white, ocellar tubercle and posterior orbits above with black bristles, mesothorax with black hair and bristles. Scutellum with abundance of long white hair on the disc and numerous mostly white bristles on the margin, wings hyaline, furcation of the third vein distinctly anterior to the vein which closes the discal cell, but plainly beyond the middle of the distance between this vein and the anterior cross-vein, stump of the anterior branch much longer than the basal section. Femora black, tibiæ yellowish red with the extreme apexes dark, tibiæ dark red, legs with white hair and black and white bristles. Abdominal segments one, two and basal part of three black in ground color and only sparsely hairy, apical part of three and all of four and five densely silver-white and white hairy, parted at the middle and directed outward, six and seven silvery with very short hair. Hypopygium from dorsal view narrow on basal third, much widened apically where the width is nearly double that at the base. See Figure 14.

Female colored like the male. Abdomen shining black, each segment gray pollinose posteriorly, giving a distinct banded effect. Oviduct shining black, about as long as the last four abdominal segments.

Type male and allotype from San Diego County, California, collected by Coquillett in April. In the United States National Museum. Several other specimens of both sexes with the same data.

The inflated appearance of the apical half of the male genitalia, the nearly naked first and second abdominal segments which are black in the male, and the banded abdomen of the female suggests the species.

Erax pilosus n. sp.

Male. Total length 11 millimeters. Hair and bristles of the whole body white, except about four black bristles above the base of each wing, numerous white bristles on the margin of the scutellum; wings delicate hyaline, narrow, the third vein branches near the middle of the distance between the anterior cross vein and the apex of the discal cell, stump on the anterior branch much shorter than the basal section. Femora all black, remainder of legs red with extreme apexes of tibiæ darkened. Abdomen, except the first segment and anterior part of the second, with abundant silver-white hair parted at the middle and directed outward. Hypopygium from dorsal view of uniform width for almost basal half, then gradually widened and rounded at tip; from side view nearly uniformly convex dorsally and concave ventrally. See Figure 15.

Male type from El Paso, Texas, April 5, 1902. Collection Academy of Natural Sciences, Philadelphia.

The small size, delicate appearance, male genitalia and furry abdomen are characteristic of the species. I know of no *Erax* where the long white hair of the male abdomen extends to the tip of the seventh segment as in this one.

Erax californicus Schaeffer.

Male. Total length 24 millimeters. Vestiture of the head white, with the exception of the ocellar and occipito-orbital bristles which are black; mesothorax largely white hairy, but some black bristles near the wing bases and some short black hair on the anterior part of the dorsum. Legs long white hairy and with black bristles, femora black, tibiæ and tarsi largely red; wings hyaline, furcation of the third vein very near the middle of the distance between the small cross vein and the base of the second posterior cell, stump slightly longer than the basal section. Abdomen black, largely covered with white pollen and everywhere with white hair, longer on two, three and four and directed outward. Hypopygium from the side of nearly uniform width, rather obliquely truncate at apex, with a rounded prominence above and a tuft of white hair pointing backward below. See Figure 6.

A female from the same locality is colored like the male. Oviduct fully as long as the last three abdominal segments.

The most characteristic thing about the species is the absence in the male of distinct silvery abdominal segments, contrasting with others that are not silvery. The whole abdomen is white pollinose, but in no place is this so dense that it may be said to be silvery as in most species.

More than 20 specimens of both sexes ranging from Washington and Montana to California and Nevada, vary in size from 18 to 26 millimeters and show quite an amount of variation in the color of the tibiæ and tarsi.

The type, which Mr. Schaeffer kindly sent me for study, is in Brooklyn, and was collected in Shasta County, California.

Erax texanus Banks n. sp.

Male. Total length 23 millimeters. Head white-haired; palpi black haired, ocellar and upper orbital bristles black. Thorax with short black hair, pleura white haired. Abdomen without parted hair, the basal segment with long white hair on the sides and beneath, and the apical parts of the segments whitish pollinose, sixth and seventh silvery, sixth blackish at base. Abdomen rather long and slender, the hypopygium much narrower than the last segment, long and slender, black haired. Femora black, tibiæ reddish on basal part, black beyond, tarsi almost black, femur black haired above, beneath and the tibia white haired, except that the latter has dark hair near the tip. Wings with costa normal, third vein with end before wing tip, the fork very much before the base of the second posterior cell. Figure 43.

From Texas (Lafr.). The hypopygium is much longer than in *Erax varipes*.

Erax triton Osten Sacken.

Face yellowish-pollinose; facial tubercle prominent, with a tuft of pale yellowish hairs and bristles; palpi beset with black bristles, mixed with yellow ones; cheeks with soft, whitish hair; upper occipital orbit with a row of stiff black bristles; basal joints of the antennæ reddish, the third joint darker; arista much longer than the third joint. Thorax with a well-marked, broad, dark brown dorso-central stripe, its median line feebly marked, reddish; sides of the dorsum yellowish, with slight brassy reflections; pleuræ brownish-yellow, with soft pale hairs; scutellum yellowish-gray pollinose, with black macrochaetæ. Halteres reddish-yellow. Abdomen, male, its prevailing color, an impure, somewhat silvery, white, with a row of black triangles, the triangles gradually diminishing in size from segment two to segment five, segment six with only a brownish line in the middle; segment one blackish, with some grayish pollen on the sides; forceps rather large, elongate, reddish-brown, beset with paler hairs and with a brush of hairs on the underside, in shape like those of E. anomalus. Female, the black triangles of nearly equal size on segments two to four, occupying the whole middle of the segment and touching the hind margin with the apex; the sides of the segments filled by triangles of an impure silvery-white; on segments six and seven the lateral margins only whitish, the middle occupied by an opaque square of brownish-black; segment five forms the transition in both sexes, but principally in the male; the silvery parts of segments two to four beset with sparse white hairs, combed outwards; ovipositor comparatively short, equal to about two or two and a half of the preceding segments; legs deep reddish, with the usual appressed pubescence or whitish hairs and long, soft, whitish or yellowish hairs (especially in the male) and black bristles; femora black on the underside. Wings

with a slight yellowish-brown tinge; second submarginal cell distinctly appendiculate, rather long, its proximal end reaching considerably beyond the proximal end of the second posterior cell; no incrassation of the costa in the male. Length 23 to 25 millimeters; without ovipositor 22 to 23 millimeters, with it about 26 millimeters.

Erax argyrogaster Macquart.

Total length 22 millimeters. Vestiture of the head pale yellowish, except the palpæ bristles are black, as are some of the occipito-orbital bristles, legs largely red, femora black beneath only, bristles black; wings yellowish, branching of the third vein just beyond the middle of the distance between the small cross-vein and the base of the second posterior cell, stump about the length of the basal section. Abdomen largely white, first segment dark, second with a large black triangle, including more than half of the anterior part of the segment, third with a smaller black triangle, fourth and each following segments with a narrow black mid-dorsal line which on five, six and seven is almost obsolete. Hypopygium elongate, narrow and reddish in color.

One male from Tehauntepec, Mexico, (Sumichrast). This agrees well with Macquart's description. I have not sufficient material to make a comparative study of *argyrogaster* and *triton*, but they appear to be much alike and perhaps the same species.

Erax varipes Williston.

Total length 22 to 28 millimeters. A rather large and robust ash-colored species with pale bristles everywhere. There may be some black in front of the scutellum and on the legs and in some specimens the bristles of the legs are largely black, although in the material studied at least a few white bristles appear scattered irregularly. Hair and bristles of the whole head entirely pale, short hair on anterior part of mesothorax black, scutellum with numerous pale bristles on its margin, wings hyaline, furcation of the third vein much nearer the anterior cross-vein than the apex of the discal cell, making the second submarginal cell very long. Legs variable in color, sometimes largely reddish, but usually the femora dorsally and the tibiæ basally are reddish with the other parts dark. Abdomen nearly uniformly gray and rather short pilose in both sexes; in the male there is not much indication of the pile parting at the middle and pointing outward as in most species with which varipes appears to be most nearly related. From dorsal view male genitalia dark reddish, basally about as wide as the seventh abdominal segment, sides parallel to near the middle, then rather rapidly widened and rounded apically as in Figure 59. For lateral view see Figure 49. Oviduct mostly black, slightly longer than abdominal segments six and seven.

Specimens from Western Kansas and from Arizona.

The dorsal red stripe of each femur and the male genitalia are very characteristic of the species.

Erax interruptus Macquart.

Length 22 to 27 millimeters. General color brownish, mystax pale with a few black bristles above, palpi with black bristles, beard pale, thorax largely gray pollinose with a wide, dark mid-dorsal stripe narrowly divided before. Scutellum with many black bristles on the margin; wings reddish hyaline, legs largely reddish brown, under sides of femora and tibiæ dark, nearly black. Abdomen nearly black in ground color, yellowish-gray pollinose spots on the hind corners of the segments, not meeting at the middle on segments one to four, segments five with the posterior margin pollinose, segments six and seven wholly pollinose in the male and each with a small black triangle with the base posterior, in the female.

This cômmon species is easily known by the furcate male genitalia and the conical oviduct, not compressed as in other species of the genus and about as long as abdominal segments six and seven. See Figure 37.

It is widely distributed South, reaching from Coast to Coast, from the latitude of Kansas to Gautemala and even further south. It was one of the early North American species described and has had several names applied to it as may be seen in the list of synonyms on a previous page.

EXPLANATION OF PLATES VII, VIII AND IX.

Wing of Erax:

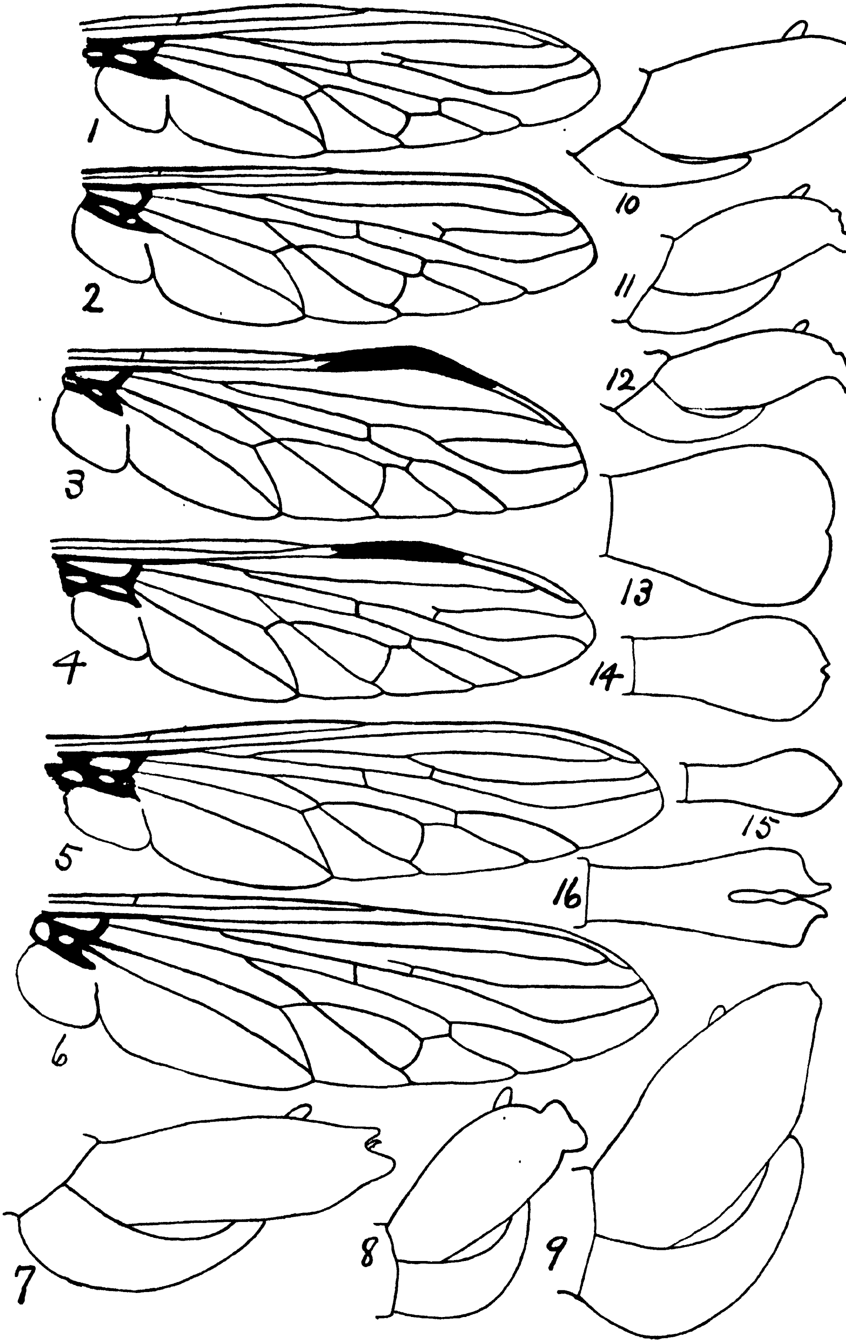
1, *stramineus;* 2, *barbatus;* 3, *jubatus;* 4, *aestuans;* 5, *anomalus*; 6, *californicus*.

Hypopygium of Erax, dorsal view:

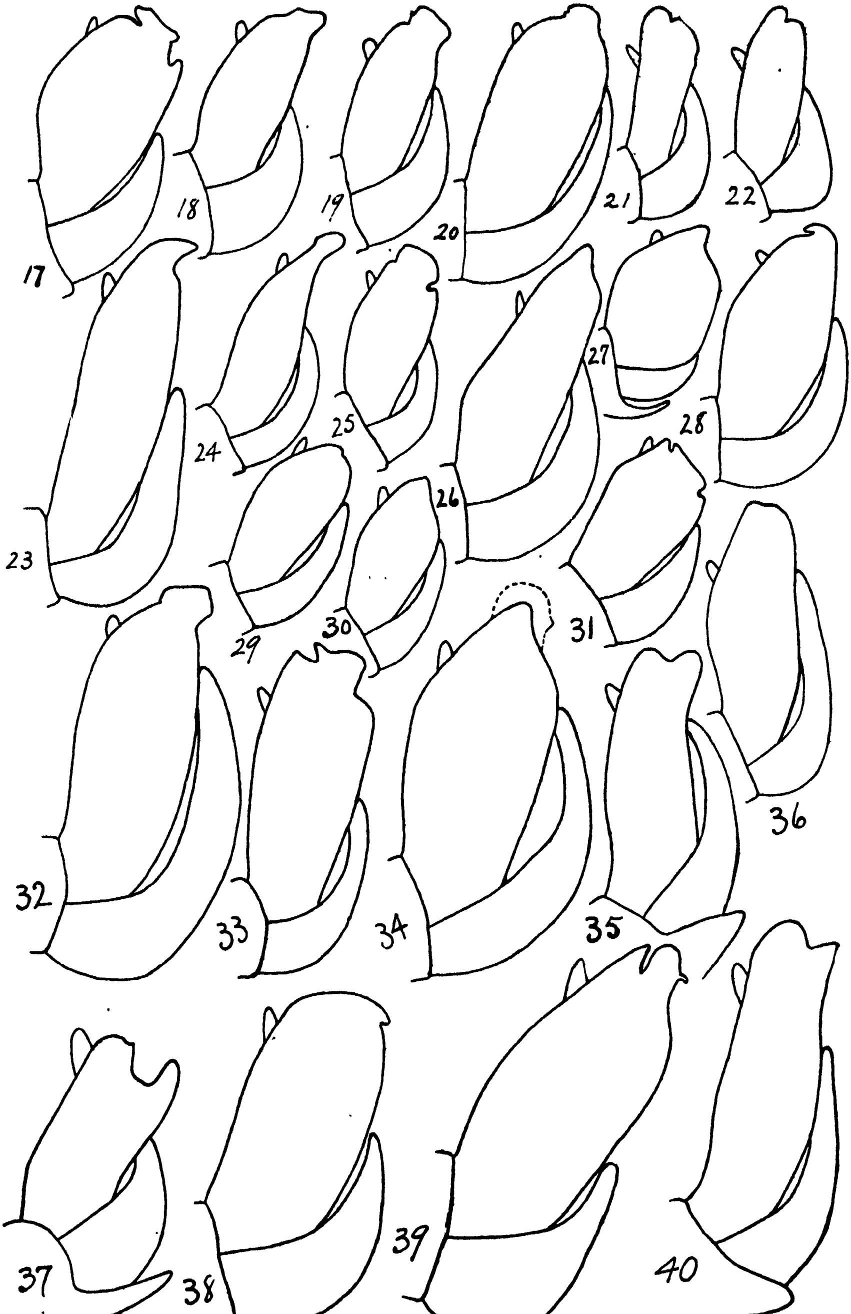
13, *prattii;* 14, *coquillettii;* 15, *pilosus;* 16, *tabescens;* 59, *varipes*.

Hypopygium of Erax, lateral view:

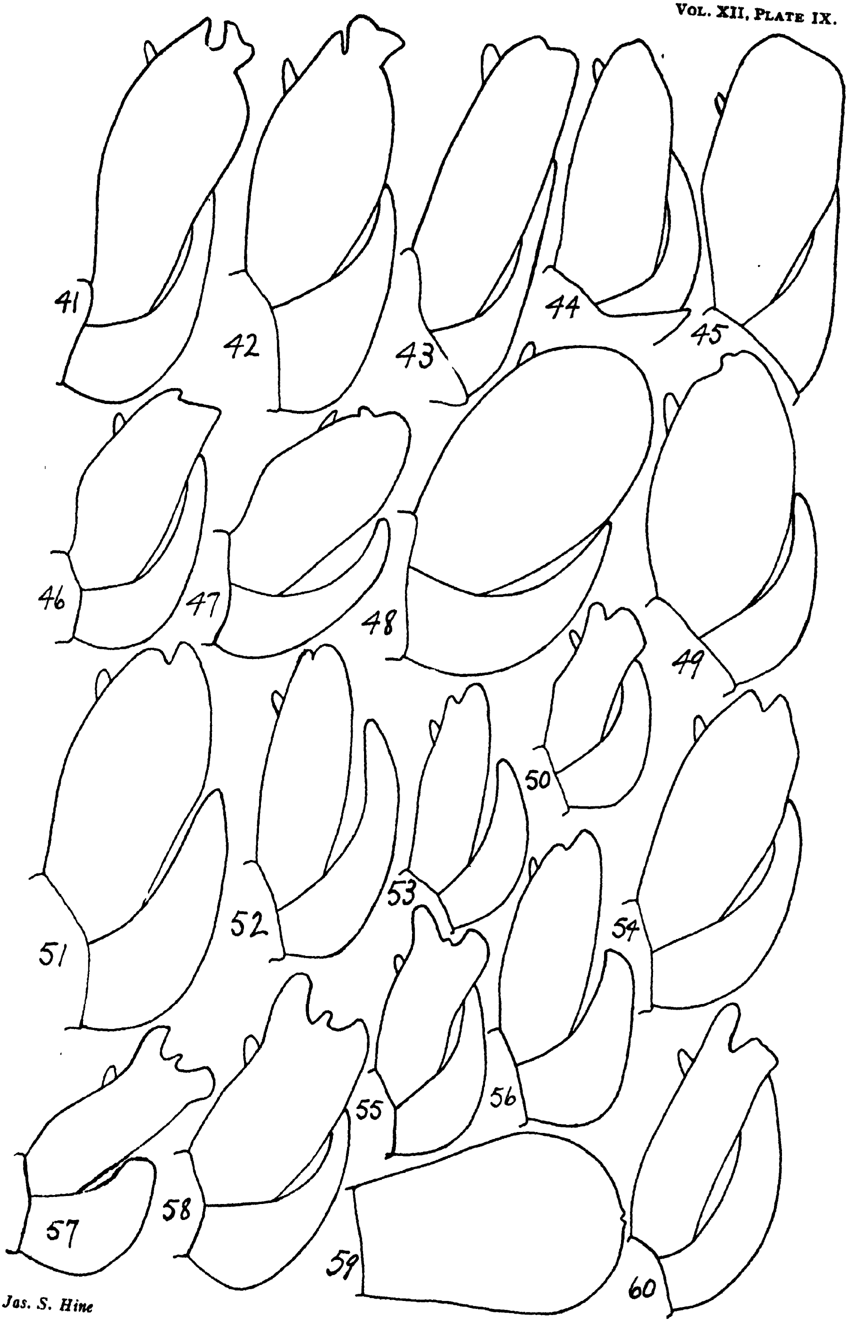
7, *willistoni;* 8, *barbatus;* 9, *bicolor;* 10, *anomalus;* 11, *candidus;* 12, *pernicis;* 17, *æstuans;* 18, *apicalis;* 19, *kansensis;* 20, *loewii;* 21, *belfragei;* 22, *aurimystaceus;* 23, *fulvibarbis;* 24, *portoricensis;* 25, *slossonæ;* 26, *tabescens;* 27, *mexicanus;* 28, *affinis;* 29, *nigritarsis;* 30, *rufitibia;* 31, *nigrimystaceus;* 32, *stylatus;* 33, *stramineus;* 34, *cingulatus;* 35, *argentifrons;* 36, *haloesus;* 37, *interruptus;* 38, *canus;* 39, *splendens;* 40, *argyrosoma;* 41, *rapax;* 42, *aurivestitus;* 43, *texanus;* 44, *pallidulus;* 45, *truncatus;* 46, *eximeus;* 47, *auripilus;* 48, *plenus;* 49, *varipes;* 50, *cressoni;* 51, *nemoralis;* 52, *subcupreus;* 53, *costalis;* 54, *jubatus;* 55, *parvulus;* 56, *latrunculus;* 57, *concinnatus;* 58, *carinatus;* 60, *unicolor*.



Jas. S, Hine



Jas. S. Hine



Jas. S. Hine

SOME CHALCID-WASPS REARED FROM CECIDOMYID GALLS.

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All except two of the species of Chalcidoidea described and listed in this paper are stated by the collectors, Mr. V. L. Wildermuth and Mr. E. G. Smyth, to have been reared from galls of the alfalfa gall-midge, *Asphondylia websteri* Felt. The two exceptions were reared from unidentified gall-making Cecidomyids, one being from a gall on *Pluchea borealis* and the other on *Suaeda* sp.

Of the species reared from galls of *Asphondylia websteri* the exact host relations of some are unknown. Some are undoubtedly primary parasites of the midge, while others are believed to be secondary upon that host. The clover seed-chalcid, *Bruchophagus funebris* Howard, was reared from some of the galls along with the parasites and it is possible that some of the parasites may have had this seed-chalcid for host. Mr. Wildermuth states that all specimens reared under Tempe Nos. 2223, 2224 and 2251 were reared from dissected *Asphondylia websteri* material and are therefore positively known to be either primary or secondary parasites of the midge. The material under Tempe No. 2264 was reared from collected galls of *Asphondylia websteri* placed in vials, and hence the host relations of this material can only be surmised. It was in the lot of material under this number that *Bruchophagus funebris* was found and it is probable as will be pointed out under discussion of the species that at least one species of parasite, *Tetrastichus bruchophagi*, came from this host.

Family EURYTOMIDÆ.

Eurytoma medicaginis new species.

Female. Length 2 mm. Head and thorax with strong umbilicate-punctate sculpture and thinly clothed with short silvery white hairs. Antennæ rather short; scape not reaching the front ocellus; pedicel conical, narrower and scarcely as long as the first funicle joint; ring-joint small; funicle five-jointed, the joints, except the first, subquadrate; the first joint slightly longer than broad, the fifth slightly broader than

long; club three-jointed, a little broader than the funicle, and not quite equal in length to the three preceding funicle joints combined, the basal joint subquadrate; second joint as long as the basal; third joint conical; ocelli in a very low triangle, the postocellar line more than twice the length of the ocellocular line; occiput immargined above, cheeks margined posteriorly; dorsal portion of pronotum very nearly as broad as the mesonotum and distinctly shorter than the mesoscutum; mesepisternum granularly rugulose, the mesepimeron indistinctly, longitudinally striate; propodeum very nearly perpendicular to the apex of scutellum, broadly but very shallowly impressed medially, the impressed area granularly rugulose; remainder of propodeum more coarsely rugose; marginal and postmarginal veins practically equal, the stigmal about three-fourths the marginal; abdominal petiole nearly twice as long as the hind coxæ, rather slender, flattened and nearly smooth above, longitudinally striate at sides and beneath, and joining the main part of abdomen ventrally, or, at least, at the antero-ventral angle; body of abdomen subglobose and ending in a short sharp point, strongly compressed from the sides, very strongly arched above the attachment of petiole as viewed from the sides, a little longer than the head and thorax combined and viewed laterally not one-third longer than thick dorso-ventrally; fifth segment the largest, approximately twice the length of fourth on the median dorsal line; ovipositor slightly exposed at tip; hind coxæ granularly rugulose like the middle of propodeum. Black; flagellum dark brown; scape brownish testaceous; coxæ and femora black; apices of femora and all tibiæ yellowish brown; all tarsi pale yellowish, claws brown; wings hyaline, venation brownish.

Male. Length 1.35 mm. Scape somewhat swollen beneath, reaching to the front ocellus; pedicel globose; between pedicel and first funicle one small ring-joint; funicle five-jointed, the joints, except the fifth, narrowed at apex into a distinct neck, each joint about twice as long as the thickened portion is thick and bearing hairs about twice as long as the length of segment; neck on apex of first segment shorter than on the other segments and the thickened portion longer; fifth segment not narrowed at apex, about twice as long as thick, with the hairs shorter than on the other segments; between each of joints two, three, four, and five of the funicle is what appears to be a very small transverse ring-joint, (visible only in balsam-mounted specimens); club two-jointed, the joints subequal in length, the apical joint ending in a very short inconspicuous nipple-like point; the propodeum is usually nearly uniformly reticulately rugose all over, the sculpture of the depressed area not markedly different from the rest of the surface; abdominal petiole longer than the hind coxæ, but not twice as long, slender, and weakly shagreened, not striate; body of abdomen small globose, hardly more than half as long as the thorax. Otherwise similar to the female, but with all tibiæ mostly blackish-brown.

Type locality, Tempe, Arizona. Type, Cat. No. 22295, U. S. Nat. Mus.

Host: *Asphondylia websteri* Felt.

Type, allotype and seven paratypes reared by V. L. Wildermuth from galls of the alfalfa midge and recorded under Webster No. 7268, Tempe No. 2251. Also a large series of specimens from the same host and locality reared by Wildermuth under Tempe No. 2264.

Antenna of type female on Hymenoptera Slide No. 781, and antennæ of a male and a female paratype on Hymenoptera Slide No. 782, U. S. Nat. Mus.

Bruchophagus funebris Howard.

Specimens of this seed-chalcid were reared by Mr. Wildermuth from galls of *Asphondylia websteri* at Tempe, Arizona, under Tempe No. 2264. Its presence in these galls is undoubtedly accounted for by the fact that it not infrequently happens that developed seeds of alfalfa are present within the gall formed by the midge and these seeds afford opportunity for the development of the *Bruchophagus*.

Family CALLIMOMIDÆ.

Callimome asphondyliæ, new species.

Female. Length 2.25 mm. Head and thorax shagreened above; face below antennæ less strongly sculptured than the vertex; antennæ rather short and thick; funicle seven-jointed, the funicle joints subequal in length, but increasing slightly in breadth toward the apex, and all joints broader than long, the first only slightly so, the last about half as long as thick; club three-jointed, not as long as the three preceding funicle joints; ocelli in a low triangle, the lateral ocellus separated from eye-margin by about the long diameter of the ocellus; parapsidal grooves complete, but weakly impressed posteriorly; propodeum without carinæ and uniformly shagreened, the sculpture not as strong as on scutellum; hind coxæ laterally sculptured like the scutellum; hind femora outwardly sculptured about like the propodeum; wings sparsely ciliated, the cilia more or less arranged in rows; stigmal vein very short, postmarginal also short; abdomen about equal to the thorax in length, the first tergite smooth, other tergites weakly sculptured, more strongly so at sides; ovipositor extending beyond the apex of abdomen about one and one-third times the length of abdomen. Color, dull blackish green, the head and thorax sparsely clothed with silvery white hairs; eyes pale reddish; face, propodeum, hind femora and the abdomen more strongly metallic than dorsum of thorax; sides of thorax and hind coxæ bluish; antennal scape and all tibiæ and tarsi brownish testaceous; flagellum, median and front femora, tarsal claws and ovipositor sheaths brownish black; wings hyaline; venation pale brownish.

Male. Length 2 mm. Tibiæ all dark brown. Otherwise agrees with the female except the general color is perhaps a little darker.

Type locality, Tempe, Arizona. Type, Cat. No. 22296, U. S. Nat. Mus.

Host, *Asphondylia websteri* Felt.

Six females and two males reared by V. L. Wildermuth from galls of the alfalfa midge under Webster No. 7268, Tempe No. 2251. May be a secondary parasite of *Asphondylia*, but is more likely primary.

Syntomaspis medicaginis, new species.

Closely resembles *Syntomaspis thalassimus* Crosby, but differs by having the antennal scape pale testaceous, the face more deeply concave and more hairy, the mesoscutum and scutellum more deeply and closely sculptured and therefore less shining, the axillæ a little more widely separated and the tibiæ not so dark.

Female. Length 2 mm. Face more than ordinarily deeply concave, rather strongly sculptured and closely set with silvery hairs; lateral ocelli separated from the eye-margin by about the diameter of an ocellus or a little less; first joint of funicle a little broader than long, following joints decreasing gradually in length outwardly; club barely longer than the two preceding funicle joints; mesoscutum, axillæ and scutellum deeply, closely reticulate-punctate, subopaque; cross furrow on scutellum distinct, the surface behind the cross-furrow reticulately sculptured but not quite as deeply and finely so as the rest of scutellum; propodeum weakly reticulated, shining, with a few foveolate punctures on the anterior margin but without carinæ, the spiracles elliptical; discal ciliation of the forewing arranged in distinct rows and confined to the area distad of a line running obliquely basad from the stigmal vein to the posterior margin; the base of wing and a broad wedge-shaped area immediately beneath and extending the whole length of marginal vein entirely bare or with only a very few very weak cilia; in the apical portion of the wing a distinct row of cilia runs from the stigmal vein in a broad curve to the apical middle of wing; abdomen very slightly longer than the thorax, distinctly though not deeply reticulated, shining, the first tergite nearly smooth, tergites one to three emarginate at the middle; ovipositor exserted the length of thorax and abdomen. Head, thorax, abdomen, coxæ and all femora metallic green, thoracic pleura and the coxæ strongly tinged with purplish or blackish; antennal pedicel and flagellum brownish-black; antennal scape, all tibiæ and tarsi and the ovipositor brownish-testaceous; eyes pale reddish; wings hyaline, venation pale yellowish.

Male. Length 1.7 mm. Agrees with the female except that the scape is somewhat metallic, the dorsum of thorax is slightly more shining, the cross furrow on scutellum less distinct, the tibiæ except at apex are all blackish with more or less of a metallic lustre, and the abdomen is much shorter and smaller than the thorax.

Type locality, Tempe, Arizona. Type, Cat. No. 22297, U. S. Nat. Mus.

Host, *Asphondylia websteri* Felt.

Type female reared by V. L. Wildermuth from galls of the alfalfa midge and recorded under Webster No. 7268, Tempe No. 2264. One paratype with the same data except Tempe No. 2251. Allotype, four male paratypes and five female paratypes reared by E. G. Smyth at Tempe from the galls of the same insect and recorded under the same Webster number. Wing of a female paratype mounted on a slide.

Syntomaspis umbilicata, new species.

In the sculpture of the thorax resembles *elegantissima* Ashmead, and *warreni* Cockerell, but is easily distinguished from both by the much shorter funicle joints, metallic colored femora and the smaller size.

Female. Length 2.5 mm. Head viewed from in front about as long as broad; face strongly sculptured with large shallow punctures; antennal depression deep and nearly smooth within, the antennæ separated at base by a carinate ridge; postocellar line equal to twice the ocellocular line, the lateral ocelli not farther from the eye-margin than the diameter of an ocellus; antennal pedicel conical, about equal in length to the first funicle joint; ring-joint a little more than twice as broad as long; first funicle joint nearly quadrate, following joints diminishing very gradually in length, the last about two-thirds as long as broad; club three-jointed, not broader than the funicle and about as long as the three preceding funicle joints; pronotum rugulose; mesoscutum with large, closely placed umbilicate punctures; surface of the scutellum before the distinct cross-furrow sculptured like the mesoscutum, behind the cross-furrow finely reticulately sculptured; propodeum polished, without carinæ and with a row of large punctures along the anterior margin; ciliation of the forewing similar to that figured for *Syntomaspis medicaginis* (ante), but not so distinctly arranged in rows, the row running from stigmal vein to apex of wing present, but very poorly defined and the wedge-shaped hairless area behind the marginal vein somewhat more restricted, there being three or four coarse cilia basad of the stigmal vein in the apex of the wedge; hind coxæ about twice as long as thick with the dorso-posterior angle weakly carinately margined; abdomen about as long as the thorax; first, second, and third tergites emarginate medially, dorsally mostly polished; the second and third at sides, and the fourth entirely, distinctly reticulate; ovipositor exserted the length of the body; color of head and thorax above dull coppery green; propodeum polished metallic green; pleura, coxæ and all femora metallic greenish-black or bluish in some lights; first three tergites above steel-blue, sides of the abdomen and dorsum beyond the third tergite brassy-green; antennal pedicel and flagellum

brownish-black, more or less metallic; scape, all tibiæ, and tarsi reddish testaceous; ovipositor sheaths black; wings hyaline, venation pale yellowish.

Male. Length 2 mm. Antennal pedicel a little shorter than the first funicle joint; first funicle joint slightly broader than long and not longer than the second; joints beyond the second very slightly diminishing in length; sculpture of scutellum like that of female but the cross-furrow not distinctly impressed; propodeum faintly rugulose with a very weak median carina; abdomen a little shorter than the thorax, the tergites not distinctly emarginate medially; scape dark above, reddish testaceous beneath; all tibiæ brownish-black; tarsi pale yellowish. Otherwise like the female.

Type locality, Tempe, Arizona. Type, Cat. No. 22298, U. S. Nat. Mus.

Female type, male allotype and two male paratypes reared by Mr. V. L. Wildermuth from galls of a Cecidomyiid on *Suaeda* species and recorded under Tempe No. 2741.

Family PTEROMALIDÆ.

Pseudocatolaccus americanus, new species.

This species is apparently very similar to *Pseudocatolaccus asphondyliæ* Masi, Boll. Lab. Zool. Agr., Portici, 3, 1908, p. 139 (—*Pteromalus polyphagus* Foerster, according to Kurdjumov, Rev. Russe d'Entom. 13, 1913, p. 7) differing principally from the description of that species in its smaller size, somewhat shorter malar space, slightly shorter antennal joints and the more acute second and third teeth of the mandibles.

Female. Length 2.5 mm. Head and thorax strongly reticulate-punctate, the sculpture of mesonotum somewhat stronger than that of the head. Head fully four times as broad as long, as viewed from above; ocelli in a low triangle, postocellar line a little shorter than the ocellocular line; as viewed from in front the head is distinctly broader than long, antennæ inserted above the lower extremity of eyes, malar space shorter than the height of eye, clypeus irregularly striate, its anterior margin sinuate; cheeks at base of mandibles distinctly concave; mandibles four-toothed, the outer tooth acute, two median teeth subacute, inner tooth blunt at apex; antennal scape cylindrical and not reaching the anterior ocellus; pedicel conical and longer than thick; three ring-joints strongly transverse, about equal in length but increasing in breadth from first to third; funicle five-jointed, the first joint about one-third longer than broad, following joints decreasing slightly in length, the fifth subquadrate or very slightly broader than long; club slightly thicker than the funicle, three-jointed, and about twice as long as the fifth funicle joint; mesoscutum much broader than long, the parapsidal grooves weakly impressed on the anterior half; scutellum

as long or a little longer than the mesoscutum; propodeum short, mostly sculptureless with a weak median carina and strong lateral folds, the spiracles elliptical and close to the anterior margin of propodeum; wings hyaline, the area before the submarginal vein with a few cilia apically; behind the submarginal bare; ciliation of the rest of wing rather sparse; stigmal and postmarginal veins subequal and each about four-fifths the length of marginal; abdomen about as long as head and thorax, conic-ovate and somewhat narrower than the thorax. Head and thorax aeneous, scape pale testaceous; flagellum dark brown; mandibles brownish; coxæ concolorous with the thorax; all femora brownish-black; all tibiæ brownish except at apex which is pale yellowish like the tarsi; apical joint of all tarsi dark; abdomen metallic blue-green at base, bronzy black beyond.

Male. Length 2 mm. Scape reaching the front ocellus, antennæ with two ring-joints and a six-jointed funicle, the funicle joints subequal and slightly longer than broad; ocellocular and postocellar lines about equal; abdomen not as long as the head and thorax; color of head and thorax metallic blue-green; all femora dark brown; all tibiæ and tarsi pale yellowish, the apical tarsal joint dark; otherwise like the female.

Type locality, Tempe, Arizona. Type, Cat. No. 22299, U. S. Nat. Mus.

Host, *Asphondylia websteri* Felt.

Described from eight females and one male reared by V. L. Wildermuth from the alfalfa midge under Webster No. 7268, Tempe No. 2251. Also one female and one male from the same locality and host reared by Mr. Wildermuth under Tempe No. 2224.

Mouthparts and antenna of a female paratype mounted on a slide (Hymenoptera Slide No. 783, U. S. Nat. Mus.) Other type material mounted on card points.

This species, according to Mr. Wildermuth, is known to be a true parasite of *Asphondylia websteri* Felt.

Trimeromicrus maculatus Gahan.

One specimen of this species, reared under Tempe No. 2223 is, according to Mr. Wildermuth, known to have been a true secondary parasite of *Asphondylia websteri*, having been dissected out of that host and then reared to maturity. Other specimens of the species were reared under Tempe No. 2264 from galls of *Asphondylia websteri* along with a number of other hymenopterous parasites and including several specimens of *Bruchophagus funebris*.

Trimeromicrus maculatus was originally recorded as a parasite in alfalfa seed-pods infested with *Bruchophagus funebris*, and subsequently proven by Mr. T. D. Urbahns to be a primary parasite upon that host. The record under Tempe No. 2223 is interesting as showing that this species may develop upon parasitic forms of Hymenoptera as well as upon the plant-feeding *Bruchophagus funebris*. In the case of the record under Tempe No. 2264 it is impossible to say whether the specimens of this species were parasitic upon *Bruchophagus*, which was shown to be present in the *Asphondylia* galls, or whether it was actually present in its role of a secondary parasite of *Asphondylia*.

Family EULOPHIDÆ.

Tetrastichus sobrius, new species.

Female. Length 1.8 mm. Face reticulately shagreened, with two longitudinal rows of shallow punctures between the antenna and eye-margin; antennal pedicel slightly shorter than the first funicle joint; first funicle joint the longest, joint two very slightly longer than three, joint three one and one-half times as long as broad and approximately three-fifths the length of the first; club short, pointed ovate, obscurely three-jointed, the first suture distinct but shallow, the second suture subobsolete; thorax finely lineolated above, the mesoscutum with a distinct complete median groove, scutellum without a median groove, but with the dorso-lateral grooves complete and distinct; propodeum very short, without any carinæ and very faintly reticulately sculptured, nearly smooth; mesopleura practically smooth, the prepectus distinctly shagreened; basal joint of hind tarsi a little shorter or no longer than the second joint; submarginal vein of the forewing with at least four or five bristles above; abdomen about one and two-thirds times as long as head and thorax, as broad as the thorax and pointed at apex, the tergites very faintly sculptured. Head, thorax, abdomen, and all femora brownish-black; flagellum brownish; scape, pedicel, all tibiæ and tarsi pale testaceous; an .obscure transverse spot in front of the anterior ocellus, also, pale; metanotum medially, more or less testaceous; wings hyaline, the venation testaceous.

Male. Length 1.3 mm. Scape of antenna a little thicker than the pedicel and about twice as long; pedicel conical, a little longer than thick; ring-joints very small, the number not discernible; funicle four-jointed, the first joint as broad as long, somewhat shorter and broader than the pedicel, second about one and two-thirds the length of the first; third and fourth joints equal and each a little longer than the second; club plainly three-jointed, about as long as the two preceding funicle joints combined, the apical joint produced at apex into a sharp point; each of the four funicle joints with a half-whorl of hairs above

near the base, the hairs three to four times as long as the joint bearing them; basal joint of club with a half-whorl of similar long hairs above near middle of joint and another half-whorl beneath and a little more basad; abdomen not longer than the head and thorax, narrower than the thorax and not pointed at apex. Antennæ entirely pale testaceous; abdomen with a large pale, nearly white spot at base above. Other characters as in the female.

Type locality, Tempe, Arizona. Type, Cat. No. 22300, U. S. Nat. Mus.

Three specimens, one female and two males, reared by Mr. Wildermuth from galls of the alfalfa gall midge, *Asphondylia websteri* Felt, under Webster No. 7268, Tempe No. 2264. Also two females and two males reared by E. G. Smyth from the same source. Antenna of female paratype and male allotype on a slide.

The host relations of this species are unknown to the writer. It may be either a primary or secondary parasite of *Asphondylia* or it may possibly have been parasitic upon *Bruchophagus funebris*, specimens of which were reared from the same lot of galls.

Tetrastichus bruchophagi Gahan.

Specimens of this species were received from Mr. Wildermuth under Tempe No. 2264, having been reared together with several other species of Hymenoptera, including *Bruchophagus funebris*, from galls of *Asphondylia websteri* Felt, collected in the field and placed in vials for rearing parasites. The species is known to be a primary parasite of *Bruchophagus funebris* and may have been present in the *Asphondylia* gall in this role. On the other hand, it is not unlikely that this species, like *Trimeromicrus maculatus*, may have developed as a secondary parasite of *Asphondylia* using some one of the primary parasites of the Cecidomyid as host.

Paragaleospomyia gallicola, new species.

It is very close to *P. eja* Girault, but differs in having the abdomen more slender, and the hind tibiæ black only on the apical half.

Female. Length 2 mm. Head, viewed from in front, slightly broader than long, the ventral margin nearly straight, cheeks slightly convex in profile; antennal depression deep and broad with a shallow subquadrate extension below the base of antennæ; ocelli in an obtuse triangle, the postocellar line about twice the ocellocular; face and cheeks

finely and weakly reticulated, the frons and vertex with similar but stronger sculpture; antennæ separated at base by a distance about equal to that between the base of antenna and the eye margin; scape slender, flattened outwardly; pedicel three times as long as thick, about equal in length to the first funicle joint and the ring-joints combined; four distinct, transverse, ring-joints; funicle three-jointed, the first joint the longest and about twice as long as thick; second joint distinctly, though not a great deal longer than broad and a little longer than the third; third joint subquadrate; club solid, and very slightly longer than the two preceding funicle joints combined; pronotum and mesoscutum strongly shagreened, parapsidal grooves deep, praescutum without trace of a median groove; scutellum more weakly sculptured than the mesoscutum, lineolate-reticulate with the paired dorsal grooves distinct, but without a median groove; propodeum rather long, distinctly, though not deeply, reticulate-punctate, slightly shining, with a distinct median carina; mesepisternum and prepectus sculptured like the mesoscutum; mesepimeron mostly polished, its dorso-posterior margin reticulated; hind coxæ strongly reticulate-punctate; abdomen as long as the head and thorax, slightly narrower than the thorax, pointed at apex, the first and basal half of second tergites polished, the apical half of second and the following tergites distinctly reticulate-punctate; second tergite a little shorter than the first; third and fourth large, subequal, and each about as long as the first. Black; flagellum brownish testaceous; scape, anterior tibiæ, basal half and narrow apical portion of median and hind tibiæ testaceous; all tarsi pale yellowish, the apical joint black; wings hyaline, venation testaceous.

Male. Length 1.25 mm. Antennal scape with a slight keel-like expansion on apical half beneath; three transverse ring-joints; funicle four-jointed, the first joint small and subquadrate or very slightly broader than long, second joint one and one-half times as long as broad, third very slightly longer than broad, the fourth quadrate; club solid, nearly as long as the three preceding funicle joints and distinctly thicker than the funicle; abdomen subpetiolate, about as long as the thorax, the first tergite a little longer than the second, smooth; second and third tergites sculptured, the third about twice as long as the second, tergites beyond the third very short. Scape black, flagellum testaceous. Otherwise like the female.

Type locality, Tempe, Arizona. Type, Cat. No. 22301, U. S. Nat. Mus.

Two females and six males reared by V. L. Wildermuth from Cecidomyid stem-galls on *Pluchea borealis* and recorded under Tempe No. 2742.

Galeopsomopsis transcarinatus, new species.

Very similar to *G. multisulcatus* Girault, but may be distinguished by the fact that the first funicle joint is the longest of the funicle joints, the true metanotum is smaller, not quite so strongly sculptured, with the

median carina less strongly developed, the submarginal vein has four to six erect hairs above instead of two, and the propodeum is slightly different.

Female. Length 2 mm. Antennal pedicel conical, a little shorter than the first funicle joint; ring-joints transverse and apparently three in number; first joint of funicle slightly longer than the second and fully twice as long as thick, second a little longer than the third, the latter ovoid and not one and one-half times as long as broad; club not quite as long as two preceding joints, ovate, distinctly three-jointed and terminating in a short spine, the joints subequal in length, but joints two and three narrowing rapidly toward apex; antennal depression deep and triangular; malar furrow basally represented by a deep rounded fovea; ocelli large, the lateral ocellus separated from the eye margin by distinctly less than the long diameter of an ocellus; a deep groove runs anteriorly from each lateral ocellus, the two grooves converging in front of the anterior ocellus; face laterad of the antennal depression and the vertex strongly sculptured; mesoscutum and scutellum lineolately sculptured; praescutum with a faintly indicated non-impressed median line, and two or three rows of pimple-like rugosities along the margins of parapsidal grooves; scutellum apparently with only an apical pair of bristles; grooves of the scutellum not deeply impressed, the sublateral pair with a few pimple-like rugosities similar to those of praescutum; metanotum faintly sculptured with an indistinct median carina; propodeum strongly sculptured all over, with a distinct median longitudinal carina and a strong transverse carina, which is more or less interrupted medially; the surface in front of the transverse carina shagreened; behind the transverse carina also shagreened but divided by several more or less distinct longitudinal carinæ; marginal vein longer than the submarginal, the stigmal about one-third the marginal and scarcely at all thickened at apex; abdomen subsessile, conic-ovate, and strongly shagreened above. Color metallic blue-green; wings hyaline; antennæ, tegulæ, wing veins and the legs for the most part pale testaceous; all coxæ concolorous with the thorax, all femora; except apically, blackish brown.

Male. Length 1.6 mm. Scape very slightly expanded beneath on apical two-thirds; apparently but one ring-joint, and this very obscure; funicle five-jointed, the first funicle joint very slightly shorter than the pedicel and a little longer than broad; second joint about one and one-half times the first; third and fourth joints subequal and twice as long as the first; fifth funicle joint longer than the first, but shorter than the second; all funicle joints narrower at apex than base, and bearing near base above a half-whorl of hairs approximately twice as long as the joints; the fifth joint has in addition a half-whorl beneath and nearer the base than the dorsal whorl which is located near the middle of segment; club two-jointed, slender, the joints subequal in length, the apical one tapering to a sharp point at apex; the basal joint of club is provided with a whorl of long hairs which are not as long as those of the funicle joints; ocelli large and narrowly separated from the eye

margin; propodeum with the transverse carina weak, especially medially; abdomen not longer than the thorax, parallel-sided or nearly, not depressed above and much narrower than the thorax. Otherwise like the female.

Type locality, Tempe, Arizona. Type, Cat. No. 22303, U. S. Nat. Mus.

Host, *Asphondylia websteri* Felt.

Type, allotype and six paratypes reared by Mr. V. L. Wildermuth from galls of the alfalfa midge and recorded under Webster No. 7268, Tempe No. 2251. Also ten specimens with the same data under Tempe No. 2264. All specimens on card points; antennæ from a female and a male paratype mounted on a slide.

Whether the species is a primary or secondary parasite of *Asphondylia* the writer is unable to state.

THE PROGRESS OF SCOLIA MANILÆ ASHM. IN HAWAII.

By F. Muir,
H. S. P. A. Experiment Station, Honolulu.

In a former article* the introduction of *Scolia manilæ* into, and its establishment in, the Hawaiian Islands was described. At that time the wasp was well established but its host, *Anomala orientalis*, was very abundant and doing great damage.

As an example of the difference between the conditions then and now the following comparisons are of interest. In 1917 from one-twentieth of an acre, 3500 *Anomala* grubs were collected from between the rows without digging around the roots of the sugar cane. Now in the same locality but over a larger area only four grubs could be found by following the plow and searching. In another locality 104 eggs, 181 grubs, 7 pupæ and 10 adults were collected from around the roots of one stool of sugar cane, now in the same locality one can only find a stray specimen after considerable search.

The parasite has extended its range beyond the area infested by *Anomala orientalis*, and is now working on *Adoretus tenuimaculatus*, a beetle common all over the archipelago.

The reduction of the *Anomala* is due solely to the action of the *Scolia* as all other factors are the same as previous to the introduction of the *Scolia*, when the *Anomala* was constantly increasing and spreading.

The phenomenal reduction of *A. orientalis* has raised the question as to the possibility of its eventual extinction. Should the *Scolia* maintain itself upon the *Adoretus* but show a great predilection for the *Anomala* such a thing may happen. The final outcome is being watched with great interest.

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*Ann. Ent. Soc. Am., X, p. 207 (1917).

NOTICE OF PROPOSED AMENDMENT TO THE CONSTITUTION OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

By Wm. A. Riley.

Article V—Sec. 3. The six additional members of the Executive Committee shall be elected for a term of three years, two members retiring each year. The six members first elected under this rule shall determine by lot their respective terms of service.

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THE ANTS OF THE GENUS METAPONE FOREL.*

By WILLIAM MORTON WHEELER.

The singular genus *Metapone* was established by Forel, in 1911†, for an ant from Ceylon, *M. greeni*, characterized by a peculiar Ponerine habitus (resemblance to *Cylindromyrmex* and *Simopone*), scrobed head, supposedly 11-jointed antennæ in the male as well as in the worker and female, one-jointed maxillary and three-jointed labial palpi, terminally spinose or dentate middle and hind tibiæ and metatarsi and what he regarded as an unusually slender, strongly segmented, non-tuberculate larva, with long sparse hairs, and stout mandibles, and pupating without spinning a cocoon. He says of this genus, which he made the type of a new tribe, Metaponini: "I regard it as constituting a special section, which I place *provisionally* among the Ponerinæ and which I call Promyrmicinæ. Perhaps later it will be necessary to transfer it to the Myrmicinæ. I reserve my opinion in regard to this matter," etc.

A year later, Emery‡ examined *M. greeni* and its larva more critically and found that alcoholic specimens of the latter when properly softened and expanded had the usual shape of body, head and mouthparts of the Myrmicine larva and were furnished with long, serially arranged, hooked, dorsal hairs unlike any known Ponerine larvæ, but like many larval Myrmicinæ He concluded that *Metapone* is a true Myrmicine ant and says: "It seems to me that the comparison of *Metapone* with *Cylindromyrmex* and *Simopone* on the one hand and *Sima* on the other,

* Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 159.

† Sur le genre Metapone n. g. nouveau groupe des Formicides et sur quelques autres formes nouvelles. Rev. Suisse Zool. 19, 1911, pp. 445–451, 1 Pl.

‡ Etudes sur les Myrmicinae. Ann. Soc. Ent. Belg. 56, 1912, pp. 94–105, 5 Figs.

as formulated by Forel should be reversed, that *Metapone* should be regarded as belonging to the subfamily Myrmicinæ and that the resemblance of the genus to *Pseudomyrma* and *Sima* is due to genetic relationship and not merely to convergent adaptation. I nevertheless accept Forel's section Promyrmicinæ but as a division of the Myrmicinæ and extend its scope to include two tribes, the Metaponini and Pseudomyrmicini." Apparently Emery reached this conclusion as a result of regarding *Metapone* as closely related to the African *Pachysima aethiops* Smith and especially to *P. latifrons* Emery.

As Forel's knowledge of the male and female of *M. greeni* was restricted to a study of pupal specimens, he could give no account of the venation of the anterior wings. In 1913, however, he described a second species, *M. sauteri*, from a female specimen taken in Formosa* and figured the fore wing, which has an open radial cell and a single cubital cell. This led him to incline to Emery's view and to suggest a resemblance between *Metapone* and the Myrmicine genus *Liomyrmex*.

In 1915 Forel described a third species of *Metapone* from Queensland, *M. mjöbergi*†, and I have since described two species, *M. bakeri*, from a female specimen taken in the Philippines‡ and *M. hewitti*, from male specimens taken in Borneo§. The latter species showed that the male *Metapone* really has 12-jointed antennæ and that Forel had evidently overlooked the second funicular joint in the male of *greeni*. Still more recently I have found two undescribed species, one from New South Wales and one from Queensland, among material sent me for study by the Museum of South Australia. Thus the genus *Metapone*, as at present known, comprises seven species.

Concerning the habits of these ants very little has been recorded. Mr. E. E. Green took the specimens of the type species "from galleries in a decayed branch, which was also infested by two species of termites." And Forel adds: "It lives, therefore, like *Cylindromyrmex*, in wood, with termites.

* H. Sauter's Formosa-Ausbeute. Formicidae II. Arch. f. Naturg. 79, 1913, pp. 183–202, 1 Fig.

† Results of Dr. E. Mjöberg's Swedish Scientific Expeditions in Australia 1910–1913, Ark. f. Zool. 9, 1915, pp. 1–119, 3 Pls. and 6 text Figs.

‡ Four New and Interesting Ants from the Mountains of Borneo and Luzon. Proc. New Eng. Zool. Club 6, 1916, pp. 9–18, 4 Figs.

§ The Ants of Borneo. Bull. Mus. Comp. Zool. 1919, 63, pp 43-147

We cannot deduce from this either that it is or is not a termitophagous species, but that it is seems very probable. At any rate, it inhabits dead branches like many termites and numerous tropical ants (*Leptogenys mucronata*, *Pseudomyrma künckeli*, etc.)"

Although none of the specimens of *Metapone*, except those of *M. greeni*, was accompanied by notes on their habits, I deem it very probable that all of the species form small colonies and live in the dead twigs and branches of trees near or actually in the galleries of termites, presumably of the genus *Calotermes* and prey on these insects or their young. That this is the case is indicated by the cylindrical shape of the body and the fact that the workers of some of the species (*greeni*, *mjöbergi* and *tillyardi*) are colored much like the termitophagous ants of the genera *Aëromyrma* and *Paedalgus*, while the females of others (*sauteri* and *leæ*), in having the head and thorax black and the gaster red, strikingly resemble the females of the termitophagous genera *Carebara* and *Ephebomyrmex*.

Returning to the question of the affinities of *Metapone*, I may say that I am unable to accept Forel's original view and that I find Emery's in part unacceptable. Forel's view is precisely stated in the two following quotations.

At page 448 he says: "The general form of the three sexes (of *Metapone greeni*) is cylindrical and altogether recalls the facies of the species of *Cylindromyrmex*. The analogy with *C. meinerti* Forel is very striking, notwithstanding the clypeus, which is absolutely different, and the postpetiole. The clypeus has a certain resemblance to that of *Simopone* in which it also terminates behind with an arcuate suture, but much less transverse and passing more posteriorly. In *Simopone* the frontal carinæ are also less separated. A certain distant resemblance to the species of *Sima* and *Pseudomyrma* is probably due to the convergence of an arboricolous life in cylindrical vegetable cavities. The relationship with the Ponerine genus *Cylindromyrmex* (*C. meinerti*) is certainly real and not due solely to the phenomena of convergence (mandibles, flat eyes placed behind the scrobes, antennæ, legs, petiole, sculpture, etc.)" And at page 452 he says: "In my opinion they (the Metaponini) should be placed directly between the Cylindromyrmicini and the Melissotarsini." The Cylindromyrmicini

are now placed by Emery with the Cerapachyi among the primitive Ponerinæ, whereas the *Melissotarsus* and *Rhopalomastix* are now regarded by both Emery and Forel as Myrmicinæ, and Forel would place them at the head of this subfamily "as being the most closely allied to the Ponerinæ."

I admit that *Metapone* closely resembles the Ponerine genus *Cylindromyrmex*, especially in the cylindrical shape of the body and head and the scrobes for the accommodation of the antennæ. Moreover, the habits of *Cylindromyrmex* and of the allied genus *Simopone* seem to be much the same as those of *Metapone*. According to Mayr*, *Cylindromyrmex striatus* Mayr (*C. brasiliensis* Emery) was collected by Hetschko in Santa Catharina, Brazil, "in wood in the galleries of a termite," and Arnold† recently described *Simopone marleyi* from three specimens taken by Marley at Durban "in hollow stems of the castor oil plant." A closer comparison of *Metapone* with *Cylindromyrmex* and *Simopone*, however, shows that the resemblances are merely superficial or convergently adaptive to this very peculiarity of habitat. The long, cylindrical body in various genera of wood-inhabiting ants is no more an indication of genetic affinities than is the similar shape so frequently and strikingly exhibited by various families of wood-boring Coleoptera (Ipidæ, Cleridæ, Bostrichidæ, Lymexylonidæ, some Erotylidæ, Trogositidæ, Buprestidæ, Cerambycidæ, Lucanidæ, etc.) As long ago as 1891 Forel seems to have been deceived by these superficial characters when he was writing his original account of the genus *Simopone*.‡ He there stated that "the resemblance of the genera *Cylindromyrmex* and *Simopone* to the genus *Sima* Roger, which belongs to the Myrmicides, is not a fact of convergence or of mimicry, but seems to me to be due to real affinities, notwithstanding the difference in the form of the pedicel. The genus *Simopone*, especially, with its very pronounced abdominal constriction, seems almost to form a transition to the Myrmicides, notwithstanding its Ponerid sting and pygidium." Here, again, the resemblance of *Cylindromyrmex* and *Simopone* to *Tetraponera* (*Sima* auct.) is manifestly due merely to similarity of habit, for the species of

* Südamerikanische Formiciden. Verh. zool. bot. Ges. Wien 37, 1887, p. 546.

† A Monograph of the Formicidae of South Africa I. Ponerinae and Dorylinæ Ann. S. Afr. Mus. 14, 1915, p. 21.

‡ In Grandidier's Histoire Phys. Nat. Polit. Madagascar 20, 1891, p. 141.

Tetraponera and of the allied genus *Pseudomyrma* live in cylindrical cavities or galleries in the branches or twigs of plants.

While I am of Emery's opinion that the species of *Metapone* are true Myrmicine ants and show no particular relationship to the Ponerinæ, I do not agree with Emery in accepting Forel's unfortunate term "Promyrmicinæ" or in associating the Metaponini as the first tribe of the Myrmicinæ with the Pseudomyrmicini in a section under that name. It seems to me that Emery is too much influenced by Forel's prepossessions. There is, in fact, little or nothing that is primitive or ancestral about *Metapone*, but much that is highly specialized and secondary, e. g., the shape of the antennæ and especially the reduction of the number of antennal joints in the male and female phases, the peculiar reduction of the palpal joints, the simplified venation of the fore wings, the peculiar structure of the petiole, postpetiole and legs, the vestigial condition of the eyes in the worker, etc. The larva is not only purely Myrmicine, but quite unlike that of *Pseudomyrma*, *Tetraponera* and *Pachysima*, as may be seen by comparison of Emery's figure (here reproduced as Fig. 2) with those in one of my recent papers.* Such study as I have been able to make of four species of the genus *Metapone* convinces me that it is an abberrant and highly specialized, though probably ancient genus of Myrmicinæ, neither primitive nor ancestral, without special affinities to the tribe Cylindromyrmicini or other Ponerinæ and moreover not even closely related to the tribes Peudomyrmicini. It should, of course, constitute an independent tribe, Metaponini, as Forel and Emery maintain, but its position among the other tribes of the Myrmicinæ is not easily determined. It might be placed provisionally between Emery's Melissotarsini and his Stereomyrmicini, which have 11-jointed antennæ in both male and female phases.

The following key will help in separating the six *Metapone* species of which the worker or female is known. *M. hewitti*, known only from the male, is redescribed below.

* A Study of Some Ant Larvae, with a Consideration of the Origin and Meaning of the Social Habit Among Insects. Proc. Amer. Phil. Soc. 57, 1918, pp. 295–343, 12 Figs.

Key to Metapone Species.

1. Clypeus with a narrow, projecting, rectangular anterior lobe, transversely truncated in front, concave at the sides, with acute tooth-like corners....2.

   Clypeus scarcely projecting anteriorly, without distinct lobe, bluntly or obscurely bidentate..5.

2. Petiole broader than long, its posterior corners blunt, flattened and lobular; postpetiole transversely elliptical or sub-elliptical; color brown..........3.

   Petiole much longer than broad, its posterior corners produced as somewhat diverging teeth which are longer than broad at their bases; postpetiole subrectangular; color black, with red or brown gaster....................4

3. Mandibles 4-toothed; mesoëpinotal suture very distinct and impressed; posterior corners of epinotum not swollen; sculpture of head and thorax rather coarse; brownish red, with castaneous gaster, female darker; length 5.9–8.9 mm..*greeni* Forel.

   Mandibles 5-toothed; mesoëpinotal suture indistinct; posterior corners of epinotum swollen; sculpture of head and thorax finer; pale brown, head darker; length, 7.6 mm................................*mjöbergi* Forel.

4. Body not greatly flattened; length 10.5–11.1 mm.; petiole and postpetiole longitudinally striate; black, with dark brown gaster.......*sauteri* Forel.

   Body much flattened; length 6.5–7 mm.; petiole transversely striate, postpetiole smooth; apical mandibular teeth smaller than the basal; brown black, with ferruginous red gaster............................*leæ* sp. nov.

5. Mandibles 5-toothed; posterior clypeal suture distinct; head and thorax longitudinally striate; petiole broadly and feebly excised behind; legs short, femora very broad; head and thorax castaneous; gaster and legs ferrugineous; length 5.5–6 mm.....................................*tillyardi* sp. nov.

   Mandibles 4-toothed; posterior clypeal suture obsolete; body very smooth and shining; petiole longer, deeply and angularly excised behind; legs longer, with narrower femora; black, with dark reddish brown legs; length 6.4 mm...*bakeri* Wheeler.

1. **Metapone greeni** Forel.

Forel, Rev. Suisse Zool. 19, 1911, p. 449, Pl. 14, ☿ ♀ ♂ and larva; Emery, Ann. Soc. Ent. Belg. 56, 1912, p. 95, Fig. 1, larva.

(Figs. 1 and 2.)

Worker. Length 5.9–8.9 mm.

Head subrectangular, nearly one and one-half times as long as broad, with subparallel sides and moderately concave posterior border. Eyes small, elongate, in the largest individuals with about 15 ommatidia in their longest and about 10 ommatidia in their shortest diameter.

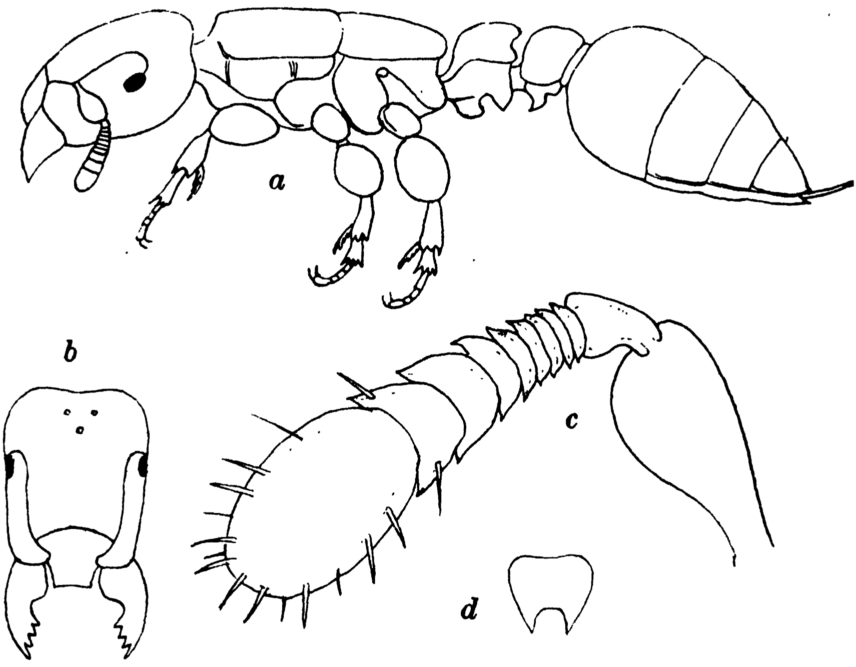

Fig. 1. *Metapone greeni* Forel (after Forel). *a*, worker; *b*, head of same from above; *c*. antenna of same; *d*, scutellum of male from above.

There are three ocellar pits, but no ocelli in the largest workers. Mandibles 4-toothed, with large basal lobe. Clypeus large, with subrectangular anterior lobe. Scape slightly surpassing the middle transverse diameter of the head, flattened and apically much dilated; funiculus much dilated and flattened at the tip, joints 2-6 at least three times as broad as long, 8 and 9 decidedly broader than long, the apical joint longer than broad and much longer than 8 and 9 together. Thoracic dorsum oblong, scarcely broader in front than behind, somewhat flattened above, submarginate on the sides. Promesonotal suture very indistinct, mesoëpinotal suture distinct and impressed. Pro- and mesonotum subequal, each one and one-half times as broad as long,

together one and one-fourth times as long as broad; base of epinotum rather longer than broad, passing through an abrupt curve into the short, subvertical declivity. Petiole subcuboidal, rather flat above, widened behind, a little broader than long, its posterior border above deeply and broadly excised, its anterior and posterior surfaces truncate, the dorsal somewhat thicker than the ventral portion. Anteriorly it has a short peduncle and its ventral surface has in front a large, longitudinal rectangular, translucent lobe, followed by a strong tooth. Postpetiole broader and shorter than the petiole, one and three-fourths times as broad as long, rounded cuboidal, bearing on its ventral side a large tooth, followed by a welt. Gaster oval; sting long and stout. Femora greatly dilated, the posterior pairs scarcely one-third longer than broad; tibiæ and metatarsi short and broad.

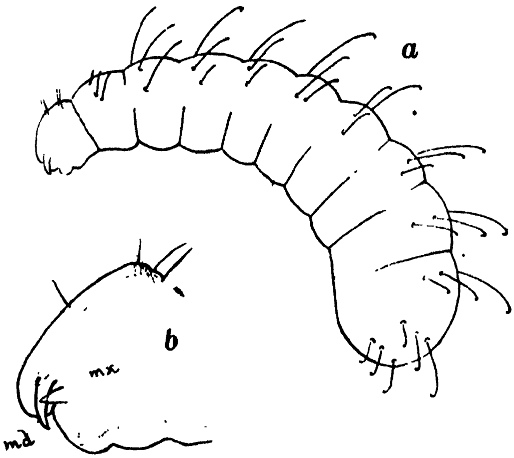

Fig. 2. *Metapone greeni* Forel. Larva (after Emery). *a*, lateral view; *b*, head of same; *md*, mandible; *mx*, maxilla.

Shining; head and thorax regularly and not coarsely longitudinally striated, with scattered, effaced punctures; the remainder of the body smooth, with fine, scattered, piligerous punctures.

Erect hairs yellowish red, short, very sparse on the body, almost lacking on the thorax, more abundant on the tibiæ and scapes. Pubescence reddish, sparse, very distinct on the gaster and pedicel, but scarce elsewhere.

Deep brownish red; gaster deep chestnut brown, sometimes blackish, with red tip. Small workers sometimes paler (immature?).

Female (mature pupa). Length 9.5 mm.

Eyes very large, occupying nearly one-half the sides of the head, moderately convex. Mesonotum and scutellum flat, small, together forming scarcely half the thoracic dorsum. In other respects like the worker, but with the head a little longer. Dark brown, nearly black.

Male (mature pupa). Length 7 mm.

Mandibles small, tridentate. Clypeus very large, convex in front, flattened behind. Head slightly longer than broad; eyes occupying more than half its sides. Frontal carinæ parallel, as far apart as they are from the lateral borders of the head. Front truncated anteriorly and separated from the preocellar space by a transverse carina connecting the frontal carinæ. Antennal scrobes small, marginate behind and laterally. Antennal scape very short, scarcely longer than broad; first funicular joint very small, globular, broader than long, the remaining joints cylindrical, the more basal a little broader than long, but increasing gradually in length, the last twice as long as broad. Thorax as broad as the head, rather flat. Mesonotum with Mayrian furrows; scutellum behind with two short, flat, horizontal teeth. Epinotum subcuboidal, its base longer than its declivity. Petiole and postpetiole as in the worker, but the former much broader than long, more rounded and not emarginate behind, with a small anteroventral tooth, the postpetiole unarmed below. Gaster elongate. Legs of the ordinary form, not dilated.

Head and thorax opaque or subopaque; longitudinally rugose, with reticulate interrugal spaces; sides of thorax striated. Clypeus coarsely and transversely rugose. Pedicel and anterior half of gaster densely reticulate-punctate and opaque or subopaque; posterior half of gaster becoming more shining. Postpetiole longitudinally rugose above and coarsely rugose on the sides like the posterior portion of the epinotum.

Erect hairs very oblique on the appendages, nearly appressed, almost absent and very short on the scapes. Pubescence somewhat more abundant than in the worker.

Black; margins of gastric segments, genital valves, tarsi, tibiæ and scapes sordid yellow or reddish; funiculi brown.

Type-locality: Peradenyia, Ceylon (E. E. Green).

2. **Metapone mjoebergi** Forel.

Forel, Ark. f. Zool. 9, 1915, p. 36 ☿ ♀.

Worker. Length 7.6 mm.

Somewhat smaller than *greeni*. Mandibles 5-toothed, their outer margin feebly convex and their basal lobe smaller. Anterior lobe of clypeus much shorter than in *greeni* and *sauteri*, but also rather rectangular. Head rectangular, about one-third longer than broad, not broader behind than at the base of the frontal carinæ, only anteriorly somewhat narrower, with nearly straight sides and feebly concave posterior border (in *greeni* broader behind and more convex laterally, longer in *sauteri*). Scape and funiculus more slender than in *greeni*, about as in *sauteri*. The very small, perfectly flat eyes have only a few indistinct ommatidia and lie as in *greeni* below the hind end of the scrobes, but are much smaller. Whole head in profile appearing as if very obliquely truncated anteriorly, i. e., with the anterior half of the clypeus much more abruptly declivous than in *greeni* and *sauteri* so

that the clypeus does not seem to stand away from the mandibles. Thorax very feebly convex, two and one-fourth times as long as broad, with parallel sides. Anterior corners of pronotum obtuse; posterior corners of the concavely emarginate epinotum protruding and swollen, a condition not seen in *greeni*. Promesonotal suture absent, mesoëpinotal suture feebly indicated (deeply impressed in *greeni*). Petiole much broader and shorter than in *greeni*, as broad as the epinotum, not quite twice as broad as long, its anterior border feebly, its posterior border deeply concave, narrower in front than behind, where its angles extend out as flat, lobular projections. It is truncated anteriorly and posteriorly and even somewhat concave in front, and bears ventrally only one strong longitudinal lobe. Postpetiole not broader than the posterior border of the petiole, scarcely one and one-half times broader than long, rounded on all sides, only about half as broad as the gaster, with two teeth below. Legs of the same shape and quite as broad as in *greeni*, the tibiæ shorter and stouter than in *sauteri*.

Sculpture of body, especially of the head, somewhat weaker and more finely longitudinally striate than in *greeni;* petiole and gaster distinctly more densely punctate. Mandibles nearly smooth, feebly striate and sparsely punctate.

The gaster and thorax exhibit a very short, fine, rather abundant, erect pilosity, which partly passes over into the pubescence and is sparser on the posterior portion of the head. There are only a few long hairs.

Pale brown, head dark brown; appendages brownish yellow.

Female (dealated). Length 7.9 mm.

Scarcely distinguishable from the worker, only much darker, brownish black, and with more distinct sutures outlining the mesonotum and scutellum. Hind corners of epinotum less protuberant, eyes large, ocelli present. Postpetiole somewhat broader than in the worker.

Type-locality: Malanda, Queensland (E. Mjöberg).

3. **Metapone sauteri** Forel.

Forel, Arch. f. Naturg. 79, 1913, p. 189, Fig. ♀.

Female. Length 10.5–11.1 mm.

Head rectangular, at least one and one-half times as long as broad, with straight sides and feebly concave posterior border. Eyes much as in *greeni*. Mandibles much longer and broader, with straight 5-6-toothed terminal border and longer and broader basal lobe. Clypeus with more distinct posterior suture, its anterior rectangular lobe much longer than in *greeni*, with perfectly straight anterior border, concave sides and acute corners. Frontal groove distinct. Antennæ very similar to those of *greeni*, but somewhat longer and narrower, especially the scape. Thorax decidedly narrower than the head, but otherwise as in *greeni*, the epinotum, however, much longer, nearly one and one-half times as long as broad, more strongly convex and less strongly marginate on the sides. Petiole also longer, much longer than broad, posteriorly with

two longer and more slender teeth, which are longer than broad at their bases. Postpetiole more rectangular than in *greeni*, nearly as long as broad. Gaster much broader, nearly twice as broad as the postpetiole, first segment nearly three times as long as the postpetiole. Lobes and teeth on the ventral surface of the petiole and postpetiole precisely as in *greeni*, also the teeth on the posterior tibiæ and metatarsi, but the femora, especially the anterior pair, twice as long as broad. Wings with a single cubital cell, a discoidal and a long radial cell, the latter slightly open at the tip; radial and cubital veins separating at the tip of the cubital cell.

Longitudinal striation of the head and thorax much as in *greeni*, but somewhat coarser, the head less punctate. Petiole and postpetiole not only punctate as in *greeni*, but also sharply longitudinally striate; the striæ on the petiole arcuate behind. Gaster shining, sparsely punctate and feebly and finely coriaceous.

Hairs sparse, reddish yellow, both erect and appressed on the body; appressed hairs on the head and thorax very scarce.

Black; antennæ and gaster dark reddish brown; tibiæ and tarsi reddish; femora and coxæ brownish. Wings brownish, with brown veins and pterostigma.

Type-locality: Sokutsu, Banshoryo District, Formosa (Hans Sauter).

4. **Metapone leæ** sp. nov.

(Figs. 3 and 4.)

Female. Length 6.5–7 mm.

Head one and one-half times as long as broad, distinctly narrower at the anterior corners than behind, the sides feebly convex and the posterior border nearly straight; the upper surface very flat, in profile about two and one-half times as long as high. Mandibles convex, their basal lobes large, their terminal borders with a series of five teeth, smallest apically and largest basally. Clypeus flat, with a long projecting median lobe, which has a straight, transverse anterior border, concave sides and acute corners. Eyes rather large, but evidently smaller than in *greeni* and *sauteri*. Ocelli small, near the occipital border. There is a longitudinal, impressed line, bordered on each side by a ruga, representing the frontal groove, extending from the posterior border of the clypeus to the anterior ocellus and growing deeper posteriorly. Antennæ rather stout, flattened; scape elliptical, somewhat more than twice as long as broad; funiculus with 3-jointed club, first joint as long as broad, joints 2-7 transverse, broader than long, terminal joint about as long as the two preceding joints together. Thorax elongate, subhexagonal, fully two and one-half times longer than broad, very flat above, four times as long as high, broader through the wing insertions where it is as broad as the head. Humeri of pronotum bluntly angular; mesonotum slightly concave behind, as broad as long, with the scutellum on the same level as the base of the epinotum, which is longer than broad, narrower behind than in front,

with straight sides and broadly and feebly excised posterior border. In profile the declivity is vertical and only about one-third as long as the base into which it passes through an abrupt curve. Petiole shaped like a mammalian vertebra, seen from above only half as broad as the epinotum at its base, one and one-third times as long as broad, with convex rounded anterior and slightly concave lateral and posterior borders, the posterior corners produced as two long blunt, diverging teeth and the middle of the posterior border above elevated as a low

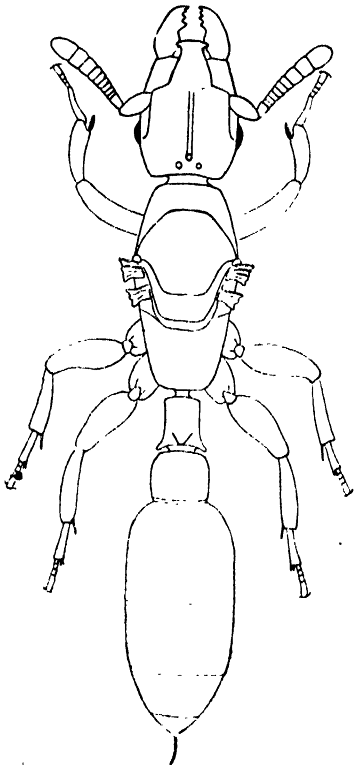

Fig. 3. *Metapone leæ* sp. nov. Female from above, with wings removed.

angular tubercle. In profile the anterior and posterior surfaces are truncated, the anterior and lateral surfaces concave, the ventral surface with two small angular, widely separated projections. Postpetiole from above nearly square, a little broader than long, a little broader than the petiole through its posterior teeth, feebly convex above, sharply truncated anteriorly, ventrally with a stout angular projection followed by a prominent transverse welt. Gaster narrow, twice as broad as the postpetiole, two and one-half times as long as broad, flattened dorsoventrally, the first segment as long as broad. Legs short, shaped much as in *greeni*, with apically dentate posterior tibiæ

and metatarsi. Wings short (5 mm. long), with the same venation as in ***bakeri***, the radial cell being slightly open at its tip and the radial and cubital veins fused for a short distance beyond the tip of the cubital cell.

Shining; mandibles smooth, finely and sparsely punctate. Clypeus, head and thorax longitudinally striate; the striæ on the clypeus fine, on the upper surface of the head separated by smooth areas, especially on the sides of the front. On the sides of the head, however, and in the scrobal cavities the striæ are very sharp and regular, and curve around the antennal insertions. Neck transversely reticulate-rugulose. Rugæ

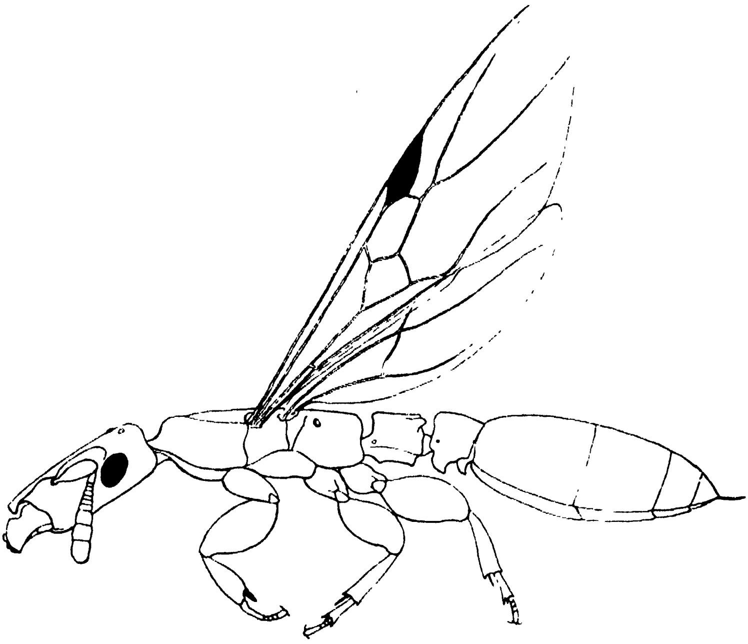

Fig. 4. *Metapone leæ* sp. nov. Female, lateral view.

on the pro- and mesonotum and scutellum sharp and regular, interspersed with a few punctures, rugæ on the base of the epinotum very fine, diverging behind, the surface also with coarse scattered punctures. Sides of thorax obliquely and finely striate. Petiole very finely and densely transversely striate above and also with a few coarse, scattered punctures. Postpetiole and gaster smooth and shining, with very fine, sparse, piligerous punctures. Legs shining.

Hairs yellowish, short, sparse, bristly, erect or suberect, of uneven length, longest on the postpetiole and gaster; pubescence coarse, very sparse on the thorax, more distinct on the gaster. Hairs on the legs short and sparse, more or less oblique.

Brownish black; mandibles, antennæ, clypeus and anterior lobes of frontal carinæ deep red; gaster and legs paler, ferruginous red; sides of thorax and lower surface of petiole and postpetiole somewhat castaneous. Wings brownish hyaline, with black pterostigma and brown veins.

Described from 22 specimens taken by Mr. A. M. Lea on Mt. Tambourine, Queensland. (Museum of South Australia).

This species is most closely related to *sauteri*, but is much smaller and is very distinct in the extremely flat, narrow body, differently sculptured petiole and postpetiole, paler gaster, etc.

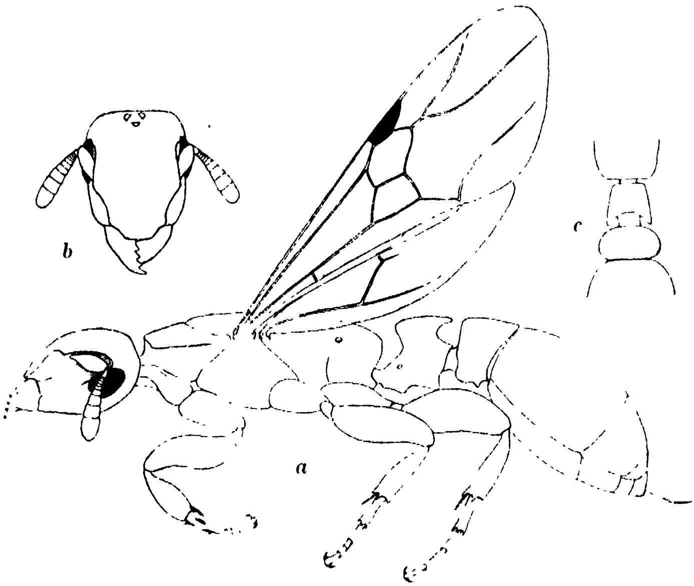

Fig. 5. *Metapone bakeri* Wheeler. Female.
a, lateral view; b, head, dorsal view; c, petiole and postpetiole.

5. **Metapone bakeri** Wheeler.

Wheeler, Proc. New Eng. Zool. Club 6, 1916, p. 10, Fig. 1. ♀.
(Fig. 5.)

Female. Length 6.4 mm.

Head less than one and one-fourth times as long as broad. Mandibles short and convex, 4-toothed, with small basal lobe. Clypeus convex, not marked off by a suture behind, its median lobe short and broad, with a blunt, tooth-like projection on each side. Antennæ with very distinct 3-jointed club, the two basal joints of which together equal the terminal joint. Thorax narrower than the head, nearly three times as long as high, its sides submarginate above; pronotum with subangular humeri, mesonotum feebly convex, together with the scutel-

lum broadly elliptical, longer than broad. Petiole from above a little longer than broad, broader behind than in front, marginate on all sides, with straight anterior and lateral borders, the posterior border deeply and somewhat angularly excised; in profile anvil-shaped, fully one and one-half times as high as long, its ventral surface with two large blunt angular projections. Postpetiole transversely elliptical, nearly twice as broad as long, ventrally with a blunt projection in front and a small tooth behind. Gaster small, suboblong. Legs short, but the femora much narrower than in the other species. Wings rather short, the radial cell narrowly open at the tip, the radial and cubital veins fused for a short distance beyond the apex of the cubital cell.

Extremely smooth and shining throughout, with sparse, very inconspicuous, piligerous punctures on the dorsal surface; posterior portion of antennal scrobes densely, longitudinally striate.

Hairs whitish, short, sparse, erect, nearly lacking on the pleuræ, most conspicuous on the gaster and legs.

Black; mandibles tinged with red; antennæ, fore legs, tibiæ, tarsi, tips and bases of middle and hind tibiæ reddish castaneous. Wings feebly infuscated, especially along the anteroapical margin; veins resin-colored; pterostigma dark brown.

Type-locality: Mt. Banahao, Luzon Island, Philippines (Prof. C. F. Baker).

This species differs from all the others in its highly polished, non-striate head and thorax, dark color, more slender legs, smaller size, etc. In my original description and figure the radial cell of the fore wing is represented as closed at the tip. It is really narrowly open. I have corrected the error in the figure as here reproduced.

6. **Metapone tillyardi** sp. nov.

(Fig. 6.)

Worker. Length 5.5–6 mm.

Head subrectangular, about one and one-fourth times as long as broad, a little broader behind than in front, with straight sides and very feebly concave posterior border. Eyes very small and indistinct, flat, at the lower posterior border of the scrobes. Clypeus rectangular, evenly convex anteroposteriorly, continuing the feeble convexity of the head, a little narrower in front than behind, with straight sides, separated behind from the head by a distinct suture, its anterior border scarcely produced as a lobe, bluntly bidentate in the middle. Each side of the clypeus overarches a cavity confluent with the scrobe and becomes continuous with the frontal carina which as in the other species extends to about the posterior fourth of the head. There is a distinct impressed line representing the frontal groove and extending to the posterior fifth of the head. Mandibles stout, their external borders rather straight, the apical border oblique, with five teeth, those at the apex largest,

the basal lobe small. Antennæ short, flattened, the scape elliptical, scarcely more than twice as long as broad; funiculus with distinct 3-jointed club, first joint longer than broad, joints 2–7 small, transverse, terminal joint a little longer than the two preceding joints together. Thorax regularly oblong, two and one-half times as long as broad, a little narrower than the head, with straight parallel sides, blunt anterior corners and concave posterior border, representing the boundary between the base and declivity of the epinotum which is square. The dorsal surface is flattened, bluntly submarginate on the sides, the pleuræ

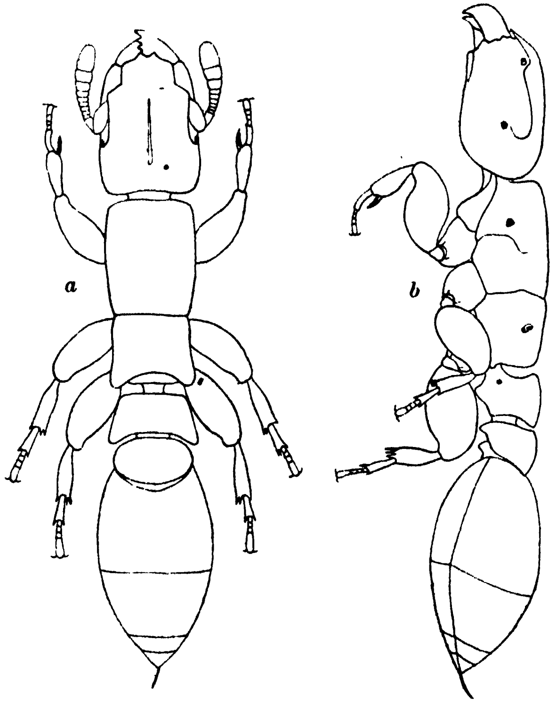

Fig. 6. *Metapone tillyardi* sp. nov. Worker. *a*, dorsal; *b*, lateral view.

concave. There is an extremely faint trace of a promesonotal suture; mesoëpinotal suture distinct, rather sharply impressed, especially on the sides. In profile the thorax is about two and one-half times as long as high, vertically truncated anteriorly and posteriorly, the latter truncation being the epinotal declivity, the sides of which are marginate but not swollen above. Petiole from above as broad as the epinotum and twice as broad as long, narrower in front than behind, with straight anterior and lateral borders and broadly excised posterior border, the posterior corners flattened and lobe-like; in profile the segment is truncated anteriorly and posteriorly, with the anterior and lateral surfaces strongly concave, the ventral surface bearing a single stout, triangular

projection. Postpetiole a little narrower than the petiole, transversely elliptical, twice as broad as long and more than half as broad as the first gastric segment, ventrally with two blunt transverse projections. Gaster short, one and two-thirds as long as broad, first segment somewhat shorter than broad. Legs very short, flattened; femora very broad, elliptical, tips of middle and hind tibiæ and metatarsi dentate as in the other species.

Shining; mandibles striato-punctate, basally smoother and sparsely punctate. Clypeus, head and thorax regularly and rather finely longitudinally striate; the posterior fourth of the head smooth and very shining. Interspersed with the striæ on the head are a few coarse punctures, arranged in rows, but becoming sparse on the occiput. The striæ on the pro- and mesonotum are somewhat finer and more regular than those on the head, on the base of the epinotum they are still finer and merge posteriorly into lines of punctures diverging to the posterior corners and into scattered punctures on the declivity. Sides of thorax obliquely striate. Petiole, post-petiole and gaster punctate, the gaster more finely. Legs smooth and shining, with very fine, sparse punctures.

Hairs yellow, in the form of sparse pubescence on the head and thorax, becoming conspicuously longer, more abundant and suberect on the gaster and especially on the sides of the petiole and postpetiole. There are also a few short erect hairs on the head and thorax. Legs with very short, rather bristly hairs, oblique on the tibiæ.

Rich castaneous brown; mandibular teeth and lateral borders of clypeus and anterior border of head black; antennæ a little paler brown; gaster and legs ferrugineous.

Described from 10 workers taken at Dorrigo, New South Wales (Museum of South Australia).

This species, which I dedicate to my friend, the eminent Australian entomologist, Dr. R. J. Tillyard, resembles *bakeri* most closely in the structure of the head and clypeus, but in color and sculpture it is more like *greeni* and *mjöbergi*, though sufficiently distinct from either.

7. **Metapone hewitti** Wheeler.

Wheeler, Bull. Mus. Comp. Zool. 1919, 63 p. 62♂.

(Fig. 7.)

Male. Length 6–7 mm.

Body long and slender. Head as broad as long, evenly convex and rounded behind, without posterior corners; cheeks very short; eyes moderately large, but not very convex; ocelli rather small. Mandibles small, but well developed, their external borders slightly sinuate basally, convex at the tips, apical and basal borders distinct, subequal, the former with four subequal teeth. Clypeus large, convex, somewhat broader than long, slightly depressed or flattened posteriorly. Front

truncated anteriorly, with a transverse crest or carina separating it from the preocellar space and connecting the frontal carinæ, which are prominent, nearly straight, subparallel and as far apart as they are from the lateral borders of the head. Posteriorly each carina curves forward medially of the eye as a distinct ridge and terminates opposite its anterior end, thus enclosing a small, shallow, elliptical scrobe about the base of the antenna. Antennæ 12-jointed; scape very small, about twice as long as broad; first funicular joint also very small, broader than long, subglobular; second joint considerably larger but also broader than long, the remaining nine joints stout, cylindrical, distinctly longer than broad, increasing somewhat in length distally, terminal joint nearly as long as the two preceding joints together, with tapering tip. Thorax long, narrower than the head through the eyes.

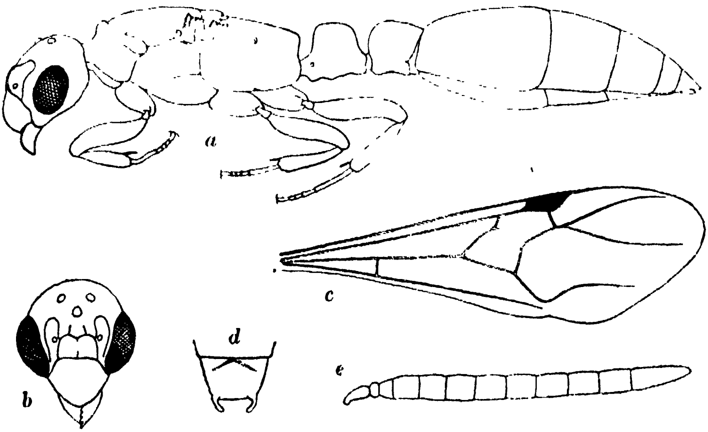

Fig. 7. *Metapone hewitti* Wheeler. *a*, male in profile; *b*, head, dorsal view; *c*, forewing; *d*, scutellum, dorsal view; *e*, antenna.

Pronotum well-developed, truncated in front; mesonotum and scutellum somewhat flattened above, the former with distinct Mayrian furrows, the latter on each side near its posterior border with a peculiar blunt, spatulate spine, slightly curved inward at the tip. Epinotum longer than broad; subrectangular from above, its base horizontal and twice as long as the vertical declivity into which it passes through an abrupt curve, the sides of the base and of the declivity above coarsely and rather irregularly marginate. Petiole with a short, stout peduncle anteriorly, and a thick cuboidal node, which is a little longer than broad and slightly higher in front than behind, with truncated anterior and posterior and rounded dorsal and lateral surfaces. Seen in profile its ventral margin is slightly bisinuate, with a small triangular tooth at the anterior end of the peduncle. Postpetiole distinctly broader than the petiole and broader than long, transversely elliptical, in profile truncated anteriorly, convex and rounded above, its ventral border unarmed, nearly straight. Gaster elongate elliptical, with straight anterior

border and tapering tip. Genitalia completely retracted; cerci apparently absent; pygidium and hypopygium short and pointed. Legs short, of the usual simple form, without the tibial and metatarsal teeth or spines of the worker and female; spurs of the middle and hind tibiæ simple, blunt at the tip. Tarsal claws very small, strongly curved, nonpectinated. Wings very short (4.5 mm.), with a well-developed discoidal cell, a single cubital cell and the radial cell slightly open at the tip. Pterostigma large and conspicuous.

Subopaque; mandibles opaque, longitudinally rugose and very finely punctate. Head reticulate-rugose, the clypeus more coarsely, though not transversely as in *greeni*. Front behind its anterior truncation with regular longitudinal rugæ converging to the anterior ocellus. Antennal scrobes less distinctly longitudinally rugose. Upper surface of mesonotum and scutellum and sides of thorax sharply and regularly longitudinally rugose, on the mesonotum with elongate, shallow foveolæ in the narrow interrugal spaces. Dorsal surface of epinotum, including the upper portion of the declivity with extremely coarse reticulate rugæ, some of which are clearly transverse. Petiole above less coarsely and even more irregularly rugose. Postpetiole and gaster very finely and densely punctate, with superimposed small, sparse and very regular piligerous punctures.

Hairs grayish brown, rather abundant, erect on the head, thorax and petiole, mostly subappressed or oblique on the postpetiole, gaster and legs. Antennal funiculi with very short fine hairs, or pubescence. Wings minutely hairy.

Black; mandibles, antennæ, legs and tip of gaster reddish brown, the tarsi slightly paler. Wings grayish hyaline with slightly infuscated tips and anterior margin; veins sharply defined, brown; pterostigma dark brown.

Type-locality: Kuching, Borneo (John Hewitt).

The four males from which this species was described were taken by Mr. Hewitt in 1908 and though they have been in my collection ever since, I was unable to assign them to any genus till Forel published his description and figures of *Metapone greeni*. Though closely related to the male of this species, *hewitti* differs nevertheless in having 4-toothed mandibles, a different sculpture, especially on the clypeus, and very different spines on the scutellum. The antennæ are certainly 12-jointed as shown in the accompanying figure. Forel evidently overlooked the second funicular joint in the mature pupal males of *greeni* which he examined. There is a possibility, of course, that *hewitti* may be the male of *sauteri* or *bakeri*, though it seems to be too small to be the male of the former and too opaque to belong to the latter species.

NOTES ON THE MALE GENITAL SYSTEM IN CERTAIN LEPIDOPTERA.*

By HERBERT RUCKES, A. M.

INTRODUCTION.

Changes going on in organisms, whether studied grossly or minutely, have always been interesting subjects and many times astonishing truths have been revealed, where they were least expected to occur.

A great deal of the work carried on in entomological histology, especially under the heading of metamorphosis, has been relative to the muscular system, alimentary tract, adipose tissue, etc., while little attention has been given to other equally important systems. This is true of the reproductive system; so for this reason a study of the morphological and histological metamorphosis of the male genital tract in certain Lepidoptera was attempted.

The study was worked out under the direction of Professor W. A. Riley, to whom the writer is indebted for his prolonged patience and valuable criticism, and for the use of prepared slides. The writer also wishes to thank Professor Lester W. Sharp for his advices regarding the subject of spermatogenesis and for the use of his slides of maturation mitosis in insects. To Mr. John R. Eyer thanks are also due for use of his valuable slides of the genitalia of a large number of Lepidoptera.

The Lepidoptera were chosen to be worked on, for the metamorphosis could be readily controlled, by artificial means; and besides, this group shows apparently a greater diversity in the form of the genital system than most other orders. The Saturniidæ were chosen because when the study was first begun, they were most abundant.

Studies in the morphology and internal anatomy of insects date back to the earliest zoologists. Dissection of forms, however, did not properly commence till the advent of the microscope, so that we find the first worker on the genital system to be Malpighi (1669) whose treatise on the internal

* Contribution from the Entomological Laboratory of Cornell University. This paper is part of a thesis (by title, On the Metamorphosis of the Genital System in the Saturniidae) presented as part requirement for the degree of Master of Arts.

structure of *Bombyx mori* Linn. is now a classic. From that date onward we find little concerning the genital system till, in 1815, Herold produced his paper on the metamorphosis of *Pieris brassicæ* Linn., including other systems besides the reproductive. This paper formed the basis for subsequent work on the genital tract for it discussed the peculiar migration of the testes to a median plane and, there, complete fusion into a spherical body. It has been proved that this condition is by no means typical of all Lepidoptera, being representative of only the higher Rhophalocera. From the time of Herold's work till 1865 seems to be a more or less stagnant period for work of this sort. In 1865 Bessels published a few observations. From the morphological point of view the greatest contributions have been given by Chlodkovsky (1880-1913). Though short, these papers are thorough and explicit, explaining the evolution of the Lepidopterous genital tracts and their genealogical relationship to those of other orders. Since 1884, histological and cytological methods, combined with a continued increase of our knowledge of chromosomes and chromosome reduction, have led to the production of a vast amount of work and a large number of observations on all groups of insects. A great deal of this work has been restricted to the study of the maturation of sex cells, regardless of the structure and function of the surrounding tissues. Those doing the most comprehensive general studies since 1884 are LaValette St. George, Verson, Blatter, Berlese, Toyama and at a recent date (1913) Zick. The views and criticisms of these authors will be discussed as their particular points come up.

METHODS AND MATERIAL.

As above stated the Saturniidæ furnished the basis of the following study, though they were by no means the only forms observed. The following is a list of species that were used:

LEPIDOPTERA.

Philosamia cynthia Drury.
Samia cecropia Linn.
Callosamia promethia Drury.
Thelea polyphemus Cramer.
Pieris (Pontia) rapæ Linn.
Anosia plexippus Linn.
Vanessa antiopa Linn.

ORTHOPTERA.

Dissoteira carolina Linn.

HEMIPTERA.

Anasa tristis DeGeer.
Euschistus fissilis Uhler.
E. variolarius Stal.
Nezara viridula Stal.

By far the greatest part of the work was done on *P. cynthia*, since it was most readily available. *S. cecropia* offered the best material to follow out morphological changes—being the largest form. Material was procured at Ithaca and New York City.

For various ends, various technique was used. The material for spermatogenesis was killed and fixed in Benda's fluid, Zenkers, Gilson's or Herman's mixtures. Pereyni's reagent was found to be very good for synaptic stages of mitosis. A new mixture, formulated as follows, fixed "ring" stages better than any of the more common solutions:

2% copper sulphate...............	3 parts
2% platinum chlorid..............	2 parts
Acetic acid........................	6–10 drops to every 100 c. c.
Water (distilled)..................	10 parts

This solution is strictly a nuclear fixer. For the study of the tissues other than the germ cells, Gilson's or Herman's mixtures were employed.

Of the stains, Weigert's copper haemotoxylin was found best, this staining cytoplasm with as much exactness as the nucleoplasm. Mallory's connective tissue stain was indispensable for the muscular and fibrous coats of the various organs, especially the coats of the testis. Delafield's haemotoxylin counterstained with picro-fuchsin was found to be very good for determining the presence of a cuticula covering.

In making dissections, especially during the larval and early pupal periods, when the organs of the genital system are very delicate and very difficult to see, the preparations were lightly stained with Delafield's haemotoxylin, the stain being dropped on the dissection after the water had been poured out of the pan. In preparations made in this way, the finer organs like the vasa deferentia, ligaments, and nerves, could be followed along their course. These structures stain deeply, while the fat lobules do not.

In order to make a more detailed study of the nerves investing the caudal portion of the abdomen, specimens were injected with 1% Grübler's "B-X" methylene blue in a .9% salt solution and allowed to remain so treated, in a living condition for from twelve to twenty-four hours. The earlier stages were found to take up the stain more readily than the adults. In adults thirty-six hours were required to have this *intra vitam* method take effect.

PARTS OF THE ADULT MALE GENITAL SYSTEM.

In insects the male reproductive system consists of a pair of testes, a vas deferens, leading from each testis into a set of ducts that vary greatly in different groups of insects (Cf. Berlese *Gli Insetti*, Figure 1087), and a penis. The testes themselves are composed of testicular tubes. These tubes may be numerous or few; in the Lepidoptera there are four; the tubes also may be separated (*Hepialus*, Fig. 1A) or they may be fused (*Philosamia*, Fig. 1 B and E, Fig. 2), and in some cases the two testes may approach the median plane and fuse *Pieris*, Fig. 1 D). In all cases the testicular tubes are homologues of the ovarian tubes. In the Saturniidæ the testes lie in a latero-dorsal position, close to the alimentary canal, just under the fifth and sixth segments of the abdomen. They are reniform in shape, the convex side of each, called the apical region, being mesad; the concave region known as the hilum lies ectad, and is the junction of the vas deferens and the four testicular tubes (Fig. 3). The vasa deferentia are long irregular tubes, extending caudad to the eighth segment, where each passes through the loop-hole of the tenth abdominal nerve (Fig. 4, Vd). After passing through the nerve each turns cephalad to the seventh segment where it unites with the seminal vesicle. The seminal vesicles we may consider as distended portions of the vasa deferentia, each joined anteriorly to a long convoluted tube known as the accessory gland; posteriorly they unite to form the upper end of the ejaculatory duct. The ejaculatory duct is really in two parts; the upper end which in early pupal stages may readily be seen to consist of two approximated short tubes (prolongations of the seminal vesicles) is known in the adult as the *ductus ejaculatorius duplex;* the posterior and longer portion, which is an invagination of the ectoderm (it bears a cuticula or chitinous lining), is known as the *ductus ejaculatorius simplex*, and terminates in a very muscular "bulb," the *bulbus ejaculatorius* at the base of the penis. This last named organ is the caudal extremity of the entire genital system. It is wholly chitinous, bearing various types of prolongations, and is connected with the body wall by means of muscles. It is capable of extrusion during copulation. (The adult system is figured in Fig. 1E).

Of the parts of the reproductive system, the germ cells, the ductus ejaculatorius simplex, and the penis are formed from the ectoderm. The remaining organs, and the muscular covering of the ductus ejaculatorius simplex are derived from the mesoderm.

ECTODERM	MESODERM
Germ cells (Verson's Cell) ? Epithelium of ejaculatory duct simplex Penis	Testicular coats (Verson's Cell, or Follicula repithelium)? Accessory glands Vasa deferentia "Ejaculatory duct duplex" Muscles of all the above. Muscles of the ejaculatory duct simplex

The origin of the various organs, and their constituent tissues has been a problem of great importance in insect embryology. It is not the purpose of this paper to deal with the various views set forth by embryologists, but to confine the remarks to post-embryonic development.

THE NERVES.

The nerves innervating the reproductive organs are complicated and deserve special mention. Their development and changes occurring in them during the pupal and adult periods are subjects that well deserve detailed study. Some interesting features are as follows.

In the early pupal stage (Fig. 4), the seventh abdominal ganglion is closely approximated to the eighth plus tenth ganglia, near the caudal portion of the seventh abdominal sternite. Three pairs of nerves arise from the seventh ganglion; these are the seventh anterior, going to the seventh spiracles, the seventh posterior going tó the body tissue, and the seventh splanchnic or sympathetic, also innervating the seventh spiracles. The posterior nerve is somewhat reduced (vestigial); this is frequently the case in Lepidoptera.

The caudal ganglion, which apparently is a fusion or condensation of the eighth, ninth and tenth ganglia, gives rise to three or four pairs of nerves. The most cephalic of these is the eighth sympathetic, which innervates the vestigial eighth spiracle. The next nerve has two branches, a long heavy one (undoubtedly the eighth anterior) passes to the eighth spiracle,

while the shorter and weaker branch (the eighth posterior) extends into the body tissue. In *Samia cecropia*, the ninth nerve arises separately from the ganglion. In *Philosamia cynthia*, it is joined for a distance with the tenth nerve. In either case, this nerve has two branches, a long anterior branch, which extends caudad to the juncture of the seminal vesicles, and the vasa deferentia, innervating this juncture, and forming a prominent plexus there. This may be called the *vesicular plexus* (Vp. Fig. 4). The shorter branch is homologous with the shorter branches of the seventh and eighth nerves and is no doubt the ninth posterior. The tenth nerve is very heavy and long. It is the most interesting of all; the strong anterior branch extends caudad, to the region of the vesicular plexus, where it forms a prominent loop hole, through which the vas deferens passes; this nerve continues and gives rise to delicate branches that form what may be called the *caudal plexus* (Cp. Fig. 4), innervating the tissue that later becomes part of the genital appendages. From each loop hole a delicate branch extends entad, and unites with the vesicular plexus. The tenth posterior nerve passes caudad, and supplies the same tissue that the caudal plexus innervates.

What changes take place during the transformation stages have not been studied. The caudal plexus no doubt forms the nerve supply for the genitalia, and the vesicular plexus probably controls the muscles of the ducts.

HISTOLOGY OF THE TESTIS.

As previously stated, each testis consists of four chambers, or testicular tubes, combined, and surrounded by a capsule. Regardless of the form of a testis, from the histological aspect, one may consider it as consisting of two main parts, an ectodermal part of the sex cells themselves, and a mesodermal portion comprising the follicular epithelium and the various coats that make up the wall of the testis. A study of the sex cells involves observations on their origin, growth, maturation and transformation, topics that come under the heading of spermatogenesis and which are not to be treated in this paper. (Cf. Pauline Dederer, Biol. Bull., Vol. 13—*Spermatogenesis in P. cynthia*). The author wishes to deal solely with the mesodermal tissue. This may readily be considered under two headings,

the follicular epithelium and the testicular envelopes. It is simpler to treat, first, the envelopes, and then consider the epithelium, since the latter needs some explanation.

In studying the testicular chambers, one finds that their lining consists of a thin structureless membrane, which is the basement membrane (Bm.—Figs. 5, 6, 7), of the follicular epithelium; the distribution and function of the follicular epithelium will be explained later. Outside of the basement membrane is a prominent wall, which in the Lepidoptera, in general, consists of two heavy layers, an inner testicular tube coat (Ttc.—Fig. 5, 6, 7) and an outer capsular coat (Cc.—Fig. 5, 6, 7). Besides these on the periphery of the capsular coat is a thin layer of material that is apparently chitinous in nature and is probably due to the degeneration of tracheæ, which are very abundant on the testis and ramify freely over its surface.

The Testicular Tube Coat (Figs. 5, 6, 7). Of the two layers forming the wall of the testis, the inner one, or testicular tube coat, is the more interesting. The coat not only surrounds the entire testis but sends three partitions or septæ toward the hilum, forming the four chambers or testicular tubes. The cells composing this layer are very peculiar. They are of mesodermal origin, and assume the appearance of true connective tissue. They render the coat loose in its texture and fibrous in its nature. In most cases (in Lepidoptera) the cells are separated from one another, leaving large intercellular spaces in which delicate cyloplasmic fibres, from the periphery of the cells, ramify and anastomose. These two features give the coat its loose and fibrous appearance. The shape of the cells varies according to the species of insect studied. In *P. cynthia*, they are elongated and spindle shaped, in *C. promethia*, they are angular, less elongated, closer and have fewer cytoplasmic prolongations. The cytoplasm in all cases is drawn out and fibrous in nature. What is more interesting than the position of the cells as to shape and texture, is their content. They are apparently storage tissues, either for reserve materials or for products of katabolism. In the case of the Saturniids they have a prominent fat content (Fd.—Fig. 5, 6). The fat globules show very plainly and beautifully in osmic acid preparations. When stained with Mallory's C. T. stain, they stand out as brilliant orange or orange-red droplets in the pinkish cytoplasm. In *Pieris*, *Lycaena*, and species in which

the testes are colored, this coat is the repository for the pigment granules (Pg.—Fig. 7), which are believed to be waste products of urate character. Fine purplish and brown granules can be readily observes in small bits of this coat torn from the testis of *Pieris* larva and viewed in toto.

Through the interstices of this tissue, tracheæ having passed through the capsular coat, branch and ramify. These tracheæ also pass through the basement membrane into the chambers of the testis, there to resolve themselves into tracheoles which lie in close relationship with the groups of spermatocysts. This condition is to be expected since the sex cells are rapidly growing bodies, and consequently need relatively large amounts of oxygen for metabolism. Choldkovsky (1880), stated that the tracheæ never penetrate the basement membrane, and enter the follicular chambers. Koschevnikoff (1891) disproved this statement for *Apis mellifica*, and the present writer has found that each testicular chamber has small masses of tracheoles in it, which can be traced back to the tracheæ passing through the basement membrane, usually the membrane lying approximate to the septæ.

The Capsular Coat. Less interesting than the testicular tube coat is the capsular coat, surrounding the entire testis, and in some cases easily separated from its inner neighbor. Usually about the same in thickness as the inner coat, this outer layer of cells shows a marked contrast, in view of the nature of the cytoplasm and the compactness of the tissue. The layer stains poorly, but on close examination, it may be seen that the cytoplasm is very spongy and granular. The cells are usually cuboidal, and very closely placed. They may be only one layer of cells, as in *C. promethia* and *Pieris rapae.* The nuclei are usually spherical and centrally placed. There is no pigment or fat distributed in the outer coat.

As mentioned above, over the periphery of the capsular coat lies a layer of structureless material that has all evidence of being chitin or of chitinous origin. It is flakey, tough and readily stains with iron haemotoxylin, picro-fuchsin, and aniline blue. It originates probably through the degeneration of the tracheæ which are abundant over the surface of the testis. In breaking down, the chitin composing the tenidia becomes chemically changed, assumes a plastic consistency, and flows

together to make a homogeneous cover over the entire reproductive gland. This layer may readily be called the *tracheal membrane* (Tm., Figs. 5, 6, 7).

The Follicular Epithelium. So much for the coats of the testis. Each of the four tubes in each testis, is the male homologue of each ovarian tube. Therefore there must be a follicular epithelium. Previously it was stated that the lining of each chamber consisted of a delicate basement membrane. The basement membrane in all epithelia is on the ental periphery of the cells. Hence, the follicular epithelium must be somewhere inside of the follicular chamber. Where is it and what is its nature? That is the question that has puzzled a great number of workers on this subject.

Verson (1889) described a peculiar cell occurring in the apical region of each testicular chamber of certain insects. Other authors (La Valette St. George, Spichardt, Tischomiroff) have studied this cell (called Verson's cell, Spichardt's cell, la cellule geante, the apical cell, etc.), and have given various interpretations as to its structure and function.

Balbiani (1866) is probably the first to have noticed this peculiar structure; he considered it a mother cell for the spermatogonia. Spichardt (1886) regarded the element in question as the primordal germ cell, forming nuclei at its periphery.

Verson, in studying *Bombyx mori*, explained that this peculiar gigantic cell, produced protoplasmic extensions, fibrous in nature, that formed a complete meshwork throughout the testicular chamber. In the meshes of this net, the spermatogonia are at first scattered, then they become collected, and finally a spermatocyst or a group of germ cells surrounded by a capsule, is formed.

Verson believed, however, that the giant cell was a primordal spermatogonium. Cholodkovsky (1894) upheld the view of Verson.

Toyama (1894), in studying *Bombyx mori*, believed that there occurred, in the apical portion of each chamber, an invagination of the testicular wall, carrying with it an enlarged and specialized cell, which later lost its connection with the coat of the testis. This became the stellate cell, described by Verson. It had no genetic relationship with the spermatogonia.

LaValette St. George (1897) believed that Verson's cell was simply a transformed spermatogonium (hence, a sister and not a mother-cell to primary germ cells), giving forth prolongations that became the spermatocyst capsules.

Tichomiroff (1898) probably added the most to the studies of the apical cell. He definitely proved it to give rise to the capsules of the spermatocysts; it had no genetic relationship with the sex cells, it gave off nuclei to the capsules, and was in nature connective tissue.

Truly, to try to understand the significance of Verson's cells, from simply a study of the testes of the Lepidoptera, would be very difficult and confusing. By making comparisons with the structures of the testes of other insects, the true homology of the apical cell may be understood.

In most insects there is a thin, delicate layer of cells lining the testicular chamber, this layer, it has definitely been shown, gives rise to the spermatocyst capsule, by sending into the interior of the chambers, delicate protoplasmic prolongations that envelop groups of spermatogonia. This layer, frequently called the *cystogenous tissue*, is nothing more or less than the follicular epithelium of the testis, and comparable in all respects with the follicular epithelium of the ovarian tubes. In the Lepidoptera the state of affairs is so modified as to present an apparent absence of follicular spithelium. Comparative anatomy shows, however, that the capsular tissue in one case arises from a definite epithelium, while in the other it arises from a single enlarged apical cell. Homologizing, then, Verson's cell (Fig. 7), must be a localization and reduction of the follicular epithelium, playing the same role, i. e., that of nutrition, as does the epithelium in the ovary. Due to this special disposition of the epithelium it has lost its characteristic form and assumed a condition somewhat fibrous and similar to connective tissue.

Most investigators have missed the significance of Verson's cell, because they did not study it in stages early enough. It no doubt arises from the mesoderm, as does the follicular epithelium in the female, and only during embryonic development can its disposition be thoroughly understood.

In the larval stages, after all the spermatogonia have been gathered into spermatocysts, the apical cell disintegrates, for it is no longer needed. The capsule of each spermatocyst can readily offer all the nutriment that is needed by the growing germ cells (Fig. 8).

THE HISTOLOGY OF THE GENITAL TUBES.

A. VAS DEFERENS.

From each testis the vas deferens extends caudad to the seminal vesicles. In larval and early pupal stages these efferent ducts are straightish, delicate, almost invisible tubes. They look like very fine transluscent threads leading to the little papilla in the eighth segment, that later becomes the remaining portion of the genital tract. During the larval and early pupal stages, the vas deferens is uniform in diameter and possesses a prominent lumen, which is regular (i. e., without ridges) in its contour. During these stages the cellular structure is represented by Figure 9. The cells are short cylindrical or columnar, possess a rather uniformly staining cytoplasm, and show a prominent central nucleus. The chromatin of these cells occurs in irregular masses, staining prominently. These masses are rather large. The outer covering of the efferent duct may be seen as a fibrous coat that later becomes a layer of circular muscle.

As the vas deferens grows in length, it becomes convoluted; coincident with its growth in length, there is a corresponding increase in diameter. Cell division takes place very rapidly, during the mid-pupal period. In Figures 10, 11 and 12 we have represented the changes that occur during this time. At first the cells simply grow in length (Fig. 8), becoming tall-columnar; the nuclei are still very prominent and the chromatin remains in irregular masses. The cytoplasm begins to become somewhat less dense near the tip of the cells, and begins to show a vacuolated appearance. At first it was thought that this condition was an artifact due to improper fixation. Its constancy led to the abandonment of the idea. The outer coat becomes heavier.

A little later stage will show the conditions represented in Figure 11. Marked changes are beginning. Some of the cells remain stunted or are suppressed in their development. Their neighbors continue to elongate and we have at first a slight irregularity in the contour of the lumen. Parallel with this change, the cytoplasm becomes definitely vacuolate at the tips of the cells, and a change takes place in the nucleus. The chromatin begins to break up into smaller particles and these

have a tendency to round off. Whether this change has anything to do with the secretory activity of the cells the author is not prepared to say. The activity of the nucleolus was not studied. At any rate, there is a very evident change in the character of the chromatin.

Continuing a step further, we get a condition represented by Figure 12. The rapidly elongating cells crowd over one another, and we have the formation of a little nest-like mass of cells. The function of the nidus in the epithelium of the digestive tract is to replace cells, as they are cast off into the lumen. As far as was determined in the vas deferens, there is no migration of the cells into the lumen, and therefore these groups of cells should be called *pseudonidi.* The vacuolization continues, and the chromatin now appears as large granules. The nuclei remain round or oval and centrally placed.

There is a gradual, but very prominent growth of the cells in the vas deferens from now on till we reach the end of the pupal period when several changes take place rather rapidly. The pseudonidi become very prominent, and the contour of the lumen becomes markedly rigid, as figured in Fig. 16. The muscle layer has been formed and outside of it is the peritoneal membrane. The most striking feature of this stage is the structure of the epithelial cells (Fig. 12). They have become totally vacuolate, and throughout the cytoplasm occur prominent, deep staining particles that are evidently secretion droplets; where these particles come from has not been determined. The nuclei migrate to the periphery of the cell and become quite-large, but the chromatin appears in very fine granules, producing a condition that does not differentiate the nucelus very well from the rest of the cell. The nuclei assume the shape of the cell. Between the muscle layer and the cells is a prominent basement membrane.

The condition of the cells at the time of the emergence of the imago may be represented by Fig. 14. The number of secretion granules is reduced, but we have in the lumen of the duct, a whitish liquid containing also an abundance of sperms. This is the seminal fluid and has been produced by the cells of vas deferens. The lower portions of the cells show a peculiar fibrous condition of the cytoplasm. This is very difficult to illustrate. The tips still show prominent vacuoles.

After copulation, all the secretion droplets have passed from the cytoplasm and this becomes still more fibrous in its nature. The vacuoles persist at the tips. (Fig. 15).

The above described metamorphosis takes place in the upper two-fifths of the efferent duct. The lower two-fifths is somewhat similar, though the lumen remains somewhat larger, and the pseudonidi are more prominent. The middle fifth of the tube remains as it was in its larval, or early pupal condition, that of a thin, uniform duct, with cells cuboidal and without pseudonidi. Secretion takes place in the upper portion and in the lower portion of the vas deferens, but not in the middle part.

B. THE SEMINAL VESICLES.

These organs may be considered as simply distensions of the vasa deferentia; their epithelia have the same growth tendency, i. e., to form pseudonidi. However, the development of the pseudonidi is not carried as far as in the case of the efferent ducts. At the cephalic and caudal ends of the vesicles, the epithelium loses its irregular character and assumes a strict columnar condition, where it graduates at one end into the epithelium of the accessory glands and at the other into that of the ejaculatory duct. The vesicles are chambers for the retention of the semen and are not centers of secretion. This latter process is localized in the vasa deferentia.

Nussbaum (1882) originally considered the vesicles, as well as the accessory glands, ejaculatory duct and penis, as derivatives of the ectoderm. Others, who also have made extensive studies of the reproductive system, believe the vesicles to be of mesodermal origin. At any rate, they are so similar to the vasa deferentia, and sufficiently unlike the other organs, to be called distentions of the former, and therefore of a mesodermal nature.

Kochevnikow (1891) found in the seminal vesicles of the honey bee, two layers of muscle, an inner circular one and an outer longitudinal. He could find none on the vasa deferentia. In the Saturniidæ, there is one layer of muscle, this is circular, and is a continuation of that found on the vas deferens (Fig. 17).

C. THE ACCESSORY GLANDS.

In the accessory glands, the cells do not become conspicuously glandular, as might be expected from the terminology of these organs.

The cells remain columnar in character and do not form pseudonidi. They do not become vacuolate, in the same sense that the cells of the vas deferens become vacuolate. The cytoplasm presents a very spongy appearance, that is present in very young cells of the glands. At first this condition might easily be taken for a general vacuolization. Comparisons with other types of cells show that it is quite different, however. Many authors believe that there is a secretion of these organs, and that the secretion causes the formation of spermatophores. This may be true. Secretion is not as evident as in the cells of the glandular part of the vas deferens, and proceeds in a different manner.

The accessory glands differ from the organs previously discussed, in the possession of a single longitudinal layer of muscle. This in early stages of the development of the reproductive system may be continuous with the muscle of the upper end of the ejaculatory duct. This has not been definitely determined.

Koschevnikow (1891) found three layers of muscle in the glands of *Apis;* an inner longitudinal layer which may not extend the entire length of the tubes, a central circular and an outer longitudinal.

In some insects the accessory glands may actually be ectodermal in origin. Many authors do not believe so, however. If they were ectodermal, there would be a tendency toward the formation of an intima, which, as far as has been determined, does not exist in them.

D. THE EJACULATORY DUCT.

As stated previously, the ejaculatory duct consists of two parts, at least it is so considered by several authors, prominent among whom is Schroeder. The upper part is divided into two tubes, the ***ductus ejaculatorius duplex*** (of Schroeder), which are short and connect at their cephalic end with the seminal vesicles. These tubes are probably simply caudal prolonga-

tions of the seminal vesicles. Their epithelium is somewhat similar to that of the vesicles and their musculature is the same.

Passing caudad to the union of this so-called ductus ejaculatorius duplex, we find we have a change in the musculature, which now takes on a longitudinal course. (Fig. 19). For quite a distance the epithelium retains its uniform columnar appearance. The longitudinal muscle is characteristic of the *ductus ejaculatorius simplex*, which is the caudal portion leading to the base of the penis. Undoubtedly this duct is ectodermal in origin. It is an invagination of the hypodermis and bears, for more than one-fifth of its length, a prominent intima. Above the caudal fifth the chitinous lining becomes thin and indistinct and is wanting at the juncture of the ductus ejaculatorius simplex and "duplex."

The longitudinal muscle, characteristic of the upper end of the single tube, has added to it, a prominent layer of circular muscle about half way along the duct (Fig. 20). The circular muscle appears outside of the longitudinal. Toward the caudal extremity the musculature becomes very uneven and very prominent, till about the so-called "bulbus ejaculatorius," it is very heavy, and interwoven. A third, outer longitudinal layer is added (Fig. 21). Koschevnikow could not find muscle in the ejaculatory duct of *Apis mellifica*. This seems very strange, in view of the function of this organ.

The epithelium of the ejaculatory duct goes through a metamorphosis comparable with that of the vasa deferentia, i. e., it forms pseudonidi, but these are covered over with the intima. In the so-called "ejaculatory bulb," the epithelium is actually folded, assuming the appearance of the epithelium of the proventriculus.

What by some authors is called the ejaculatory bulb is in reality a continuation of the simplex duct, with abundant muscle, with no enlargement, but a reduction of its lumen. Its function is to force the seminal fluid through the chitinous penis.

CONCLUSION.

(1) The Saturniid testis belongs to Chlodkovsky's second (larval) type, consisting of four testicular tubes combined in a common capsule.

(2) The greatest changes take place during the pupal stage.

(3) The inner coat, of the testis and not the outer one, is fatty in nature.

(4) Verson's cell is a modified follicular epithelium, giving rise to the spermatocyst capsules.

(5) The cells of the vas deferens are the source of the seminal fluid, the accessory glands and seminal vesicles are storehouses.

(6) The accessory glands have a longitudinal layer of muscle; the seminal vesicles a circular layer, the upper end of the ejaculatory duct has longitudinal muscles, the lower portion has added a circular and an outer longitudinal layer as well.

(7) There is a definite and complicated innervation of the internal genital organs.

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EXPLANATION OF PLATES

PLATE X.

Fig. 1. A, B, C, D. Chlodkovsky's four types of Lepidopterous testes. A, *Hepialus;* B, *Saturnia;* C, *Lycaena;* D, *Pieris.* All diagramatic. E, adult genital system in Samia cecropia, semi-diagramatic. × 8.

Fig. 2. Sagittal section of testis, showing chambers, hilum, and two coats. Diagramatic.

Fig. 3. Detail of hilum of testis. Note the continuity of the basement membrane of the chamber with that of the epithelium of the vas deferens. Camera lucida drawing.

PLATE XI.

Fig. 4. The relation of the nervous and reproductive systems in an early pupal stage of *Philosamia cynthia.*

Fig. 5. Detail of coats of testis of *Callosamia promethia.*

Fig. 6. Detail of coats of testis of *Philosamia cynthia.*

Fig. 7. Detail of apical region of a chamber in the testis of *Pieris rapæ,* showing Verson's cell giving rise to spermatocyst capsules. The black particles in the cytoplasm of the apical cell are portions of the parent nucleus, (probably formed by amitosis) migrating to the fibrous prolongations to become the nuclei of the spermatocyst capsule.

Fig. 8. Adult (sperm stage) spermatocyst.

PLATE XII.

Figs. 9–15. Growth of the epithelium of vas deferens from larval (or early pupal) stage (9) to the late pupa, (13) when the cytoplasm contains secretion droplets, to the adult stage (15), when the secretion droplets disappear and the tips of the cells vacuolize.

Fig. 16. Trans-section of vas deferens, showing general contour of epithelium.

Fig. 17. Epithelium of upper end of seminal vesicle.

Fig. 18. Epithelium of accessory glands.

Fig. 19. A, Trans-section of ejaculatory duct, near its union with the "ductus ejaculatorius duplex." B, Epithelium of same.

Fig. 20. Trans-section of ejaculatory duct, midway along its length. Note the addition of circular muscle.

Fig. 21. Trans-section of ejaculatory duct near ejaculatory "bulb." Note the addition of muscles and the presence of an intima.

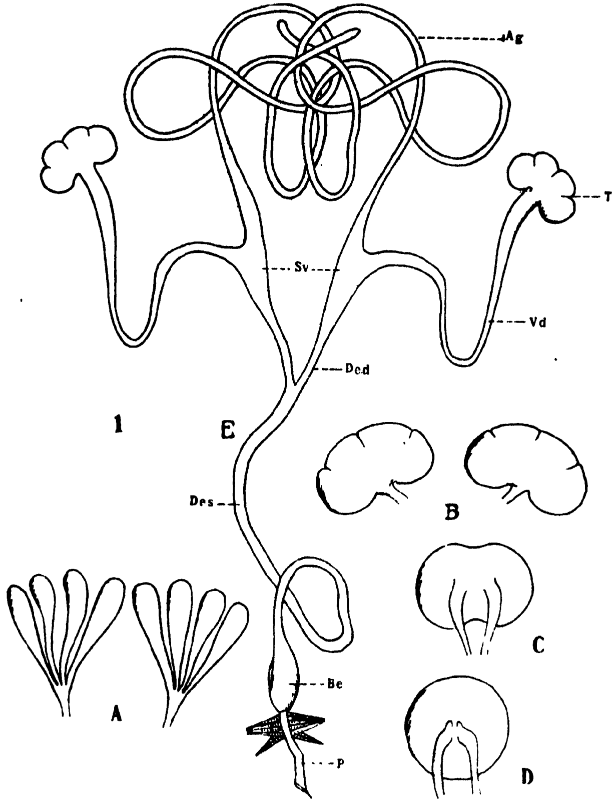
Each scale line is equivalent to 100 micra.

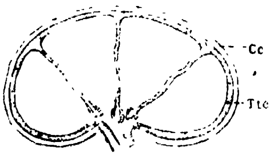
ABBREVIATIONS.

Ac.—Apical cell (Verson's cell)—Follicular epithelium.
Ag.—Accessory glands.
Be.—Ejaculatory "bulb."
Bm.—Basement membrane.
Cc.—Capsular coat.
Cm.—Circular muscles.
Cp.—Caudal plexus.
Ded.—"Ductus ejaculatorius duplex."
Des.—Ductus ejaculatorious simplex.
Epi.—Epithelium (of genital ducts).
Fd.—Fat droplets.
I.—Intima.
Lm.—Longitudinal muscles.
Lvd.—Lumen of vas deferens.
P.—Penis.
Pg.—Pigment granules.
Sd.—Secretion droplets.
Sp.—Spiracle.
Spc.—Spermatocyst capsule (follicular epithelium).
Spg.– Spermatogonia.
Spn.—Nucleus of spermatocyst capsule.
Spv.—Vestigial spiracle.
Sv.—Seminal vesicles.
T.—Testis.
Tm.—Tracheal membrane.
Tr.—Tracheæ.
Ttc.—Testicular tube coat.
Vd.—Vas deferens.
Vp.—Vesicular plexus.

FOR FIG. 4.

7, 8, 9, 10—Abdominal nerves.
A—Anterior.
P—Posterior.
S—Sympathetic.





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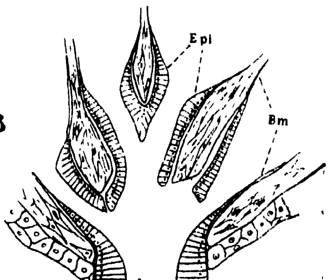

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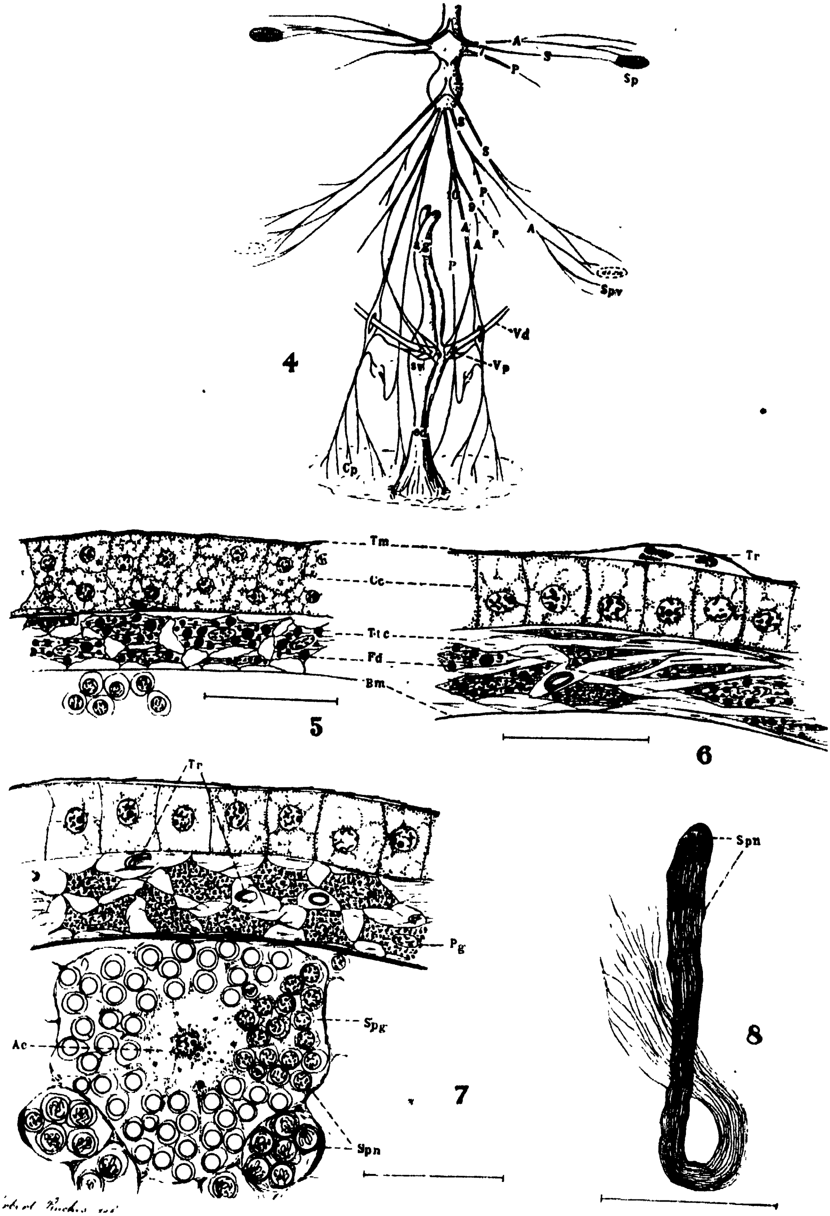

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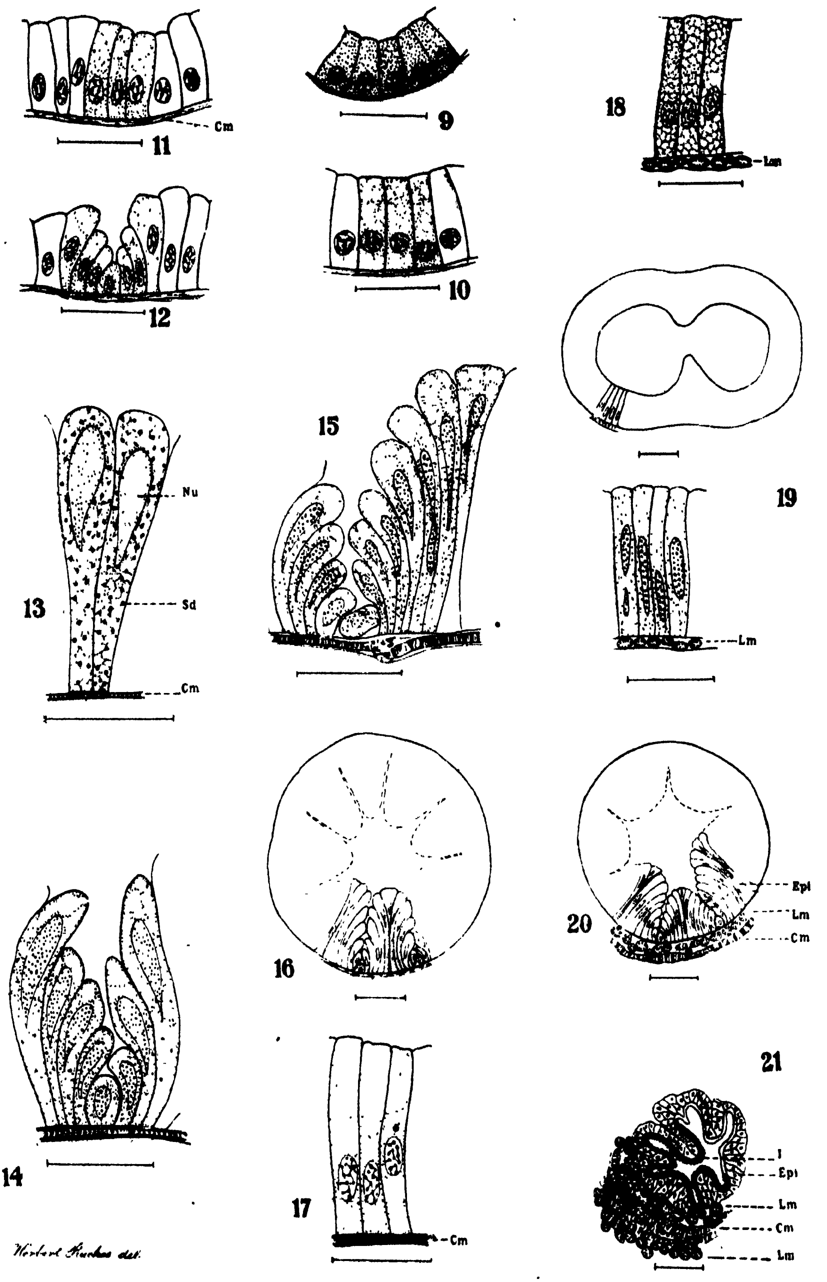

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THE AQUATIC ADAPTATIONS OF PYRAUSTA PENITALIS GRT. (LEPIDOPTERA).*

PAUL S. WELCH.

INTRODUCTION.

The unique and ingenious methods whereby aquatic animals have solved their problems of maintenance are always interesting, particularly in a group having an immediate terrestrial ancestry, as is the case with aquatic insects. It is a well-known fact that among insects all graduations between the terrestrial and aquatic species can be found, often within one family. Similar transitions are now known to exist within a single species. Some of these transitional forms, while retaining certain terrestrial habits and potentialities, have progressed far in the development of aquatic adaptations and solve the problems of the new environment with remarkable ease. While Lepidoptera are preëminently terrestrial, there exists a very small, heterogeneous group of species which presents aquatic adaptations of peculiar interest. The climax in aquatic adjustment for this group is probably represented by the gilled caterpillars of *Nymphula* (Welch, 1916). *Pyrausta penitalis* Grt., on which this paper is based, presents a striking case, not only of transition from terrestrial to aquatic habit, but also of a development of physiological adaptations which parallel closely those appearing in certain other unrelated Lepidoptera (Welch, 1914).

The field data used in this paper were secured during the summer of 1917, while the writer was a member of the Ohio State University Lake Laboratory staff. In the protected coves of Sandusky Bay, Lake Erie, particularly Beimiller's Cove, *Nelumbo lutea* grows abundantly and during July, 1917, there appeared upon this plant large numbers of the caterpillars and pupæ of *Pyrusta penitalis.* The abundance of material and the constant presence of practically all degrees of development made possible a wide range of observations in a relatively short time. Since the writer has spent but the one season at

*Contribution from the Zoological Laboratory of the University of Michigan.

the Lake Laboratory, this report is incomplete in many respects, but the data contained herein are presented with the hope that they may serve as an added basis for future work.

Several papers already published contain information on this insect, but in all of them the data are meager and fragmentary, the sum total representing a very incomplete account. Smith (1890a; 1890b) discussed it under the name *Botis nelumbialis*, giving account of the imago, mature larva, and pupa. Later, Hart (1895) described in more detail the stages of the life-history and presented a few biological features of the larva and pupa. Recently, Chittenden (1918) recorded some interesting terrestrial activities of this species.

Coquillett (1880) described what he thought to be the larva of "Botis penitalis," stating that it fed on Indian hemp (*Apocynum cannabinum*). Chittenden (1918, p. 454), however, points out a certain disagreement of Coquillett's description with the true larva of *penitalis* and suggests the probability that some other species was under observation. Dr. J. McDunnough, in a recent letter to the writer, confirms the suspected error in this record and states that the *Apocynum* feeder is the allied *futilalis* Led. and that he has bred the latter in abundance at Decatur, Illinois.

The writer wishes to express his indebtedness to Dr. J. McDunnough for confirmation of the identification of this species.

THE LIFE-CYCLE.

In the above-mentioned papers are found accounts of the full-grown larva, the pupa, and the imago and further mention is not required here. However, the eggs and place of oviposition have heretofore remained undescribed. The writer, after much searching, finally found, on July 28, a single egg-mass on the upper side of a *Nelumbo* leaf, which, when brought into the laboratory and kept in an aquarium yielded larvæ that were unquestionably those of *penitalis*. This mass was amber-colored, and approximately circular in contour, having a diameter of 3 mm. About sixty eggs were present, surrounded by an amber-colored matrix, and closely set together. On hatching, the egg-shells lost the amber color and assumed a dirty grey appearance. All of the eggs developed normally and larvæ emerged, but since the exact time of the oviposition

of the mass was unknown, the length of the egg-stage could not be determined. The young larvæ, at the time of hatching, were about 1.5 mm. long. They immediately began feeding upon the leaf in the vicinity of the egg-mass, consuming the upper surface in the characteristic manner. The surface webbing, described later, appeared very soon, subsequent development and activities continuing in the fashion normal for the species.

The difficulty of finding the egg-masses is quite puzzling since the writer examined hundreds of *Nelumbo* leaves and the amber color of the egg-mass against the green background of the leaf, if that be the usual place of oviposition, should make detection rather easy. Furthermore, the writer observed dozens of leaves each bearing very small larvæ which, it would seem, must have emerged from eggs deposited very near by, but no indications of old egg-masses were detected.

Chittenden found a considerable number of these larvæ boring into the canes of raspberries and likewise, to some extent, in the stalks of corn. However, he states (p. 455), that "there is no evidence that the species feeds on either healthy corn or raspberry, although it feeds on the pith to a considerable extent, but on the contrary develops chiefly upon lotus and other aquatic or semiaquatic plants and enters cornstalks and the cut ends of raspberry canes chiefly as a retreat for passing the winter and for subsequent transformation." This statement is not entirely clear. It seems to imply that corn and raspberry may not be affected unless in some unhealthy condition. It also appears to suggest that these larvæ pass their early development in aquatic situations and then some of them migrate to certain terrestrial plants in order to find a hibernation place. Chittenden has tried to formulate "an approximate life history" from the fragmentary bits of available information and suggested that the larvæ constitute the hibernation stage; that the adults begin emerging in March; that larvæ appear in due course of time and feed until late in August when they complete their growth, seek a convenient winter retreat and hibernate. Such a statement suggests only one generation per year.

Certain observations of the writer do not seem to corroborate the above-mentioned inferences. It was not possible to determine the hibernation stage and it may be that some of the larvæ, in late autumn, do migrate to shore and find hibernation

quarters in connection with other plants. However, *Nelumbo* often occurs somewhat remote from shore and while, as will be shown later, these larvæ are efficient swimmers, it seems rather doubtful if such is the only method. Since pupæ are found in the upper end of the *Nelumbo* petioles during the summer, the writer is inclined to suspect that hibernation, in the aquatic situations, may occur as pupæ in cocoons within the old food plants. Circumstantial evidence also seems to indicate more than one generation per year. During the first week in July, larvæ of all sizes as well as pupæ were found and from that time to early August, when the writer's observations ceased, adults were emerging continually from the *Nelumbo* petioles. Quite a number of such pupæ were reared in aquaria in the laboratory. Since these immature forms occurred in connection with the fresh leaves and petioles and were of all sizes and ages, the evidence seems clear that they were not overwintering individuals. Furthermore, the emergence of adults throughout the most of July (and possibly to some extent later) and the finding of eggs on July 28th, suggests a midsummer brood. Therefore, the writer is inclined to believe that in the region of Lake Erie the species is at least double-brooded and that hibernation may occur in connection with the aquatic food-plants.

ADAPTATIONS TO AQUATIC SURROUNDINGS.

The chief aquatic adaptations manifested in this species are related to the problems of food-getting, locomotion, and respiration—problems which are always of vital importance in the adjustment of an animal of terrestrial origin and organization to partial or complete aquatic life. While this species thrives under the conditions of its aquatic surroundings, it is interesting to note that the complete, original terrestrial organization has apparently been retained, that no structural features of aquatic importance have appeared, and that the adjustments to the water are very largely, if not entirely, physiological, consisting of habits and activities which result in the favorable solution of the problems involved. The physiological adjustments of this species to water offer a very close and interesting parallel to those of *Bellura melanopyga* Grote (Welch, 1914) a species which is remote from *Pyrausta penitalis* in kinship, but which has solved its major problems

of locomotion, nutrition, protection, and respiration not by structural developments, but by modified activities remarkably similar to those of *P. penitalis.*

FEEDING HABITS.

Food Plants.—In the Sandusky Bay region, *P. penitalis* was found only on *Nelumbo lutea.* Other plants in the same habitats and on nearby shores were examined from time to time, but appeared to be unaffected by this insect. However, it is evidently a general feeder, since other writers have reported it on *Polygonum incarnatum, Polygonum hydropiperoides, Eupatorium* (species not given), and *Nelumbo nucifera* ("Egyptian lotus"). An erroneous record of *Apocynum cannibinum* was mentioned on a foregoing page.

Leaf-feeding Period.—Two well-defined periods can be recognized in the feeding activities of the larvæ, (1) an early one, the *leaf-feeding period,* and (2) a later period, the *petiole period.* These two periods were given bare mention by Smith (1890a) and Hart (1896, pp. 180-181), but the details and adaptations have not been described.

After hatching, the young larvæ feed upon the outer surface of the *Nelumbo* leaf, removing the upper epidermis and a considerable part of the underlying chlorophyll-bearing tissue. The feeding areas are irregular and vary in size, depending upon the amount of feeding done. They often become confluent, forming large irregular areas. When first made, they are light greenish, but soon change to brown and in time the whole leaf, if heavily infested, assumes that color.

While any part of the upper leaf surface is subject to attack, feeding at the periphery differs, in certain distinct respects, from that within the periphery, and likewise involves distinct differences in accompanying adaptations. These activities will be described in the reverse order of mention.

Leaves bearing young larvæ almost invariably show, when examined critically, numerous, very fine strands of silk all over the upper surface, marking the routes of the wandering larvæ. This apparent wastefulness in silk production is perhaps the first form of aquatic adaptation to appear in the life-cycle since the silken thread continually anchors the tiny larva to the leaf during its search for an appropriate feeding place and aids in preventing it being washed off the leaf by waves or other surface

disturbances. When active feeding begins, the silk formation becomes a more noticeable and important feature. Feeding areas are surface excavations, usually with a depth greater than the diameter of the caterpillar, across which is spun a fine, somewhat substantial silk web, and under which the larva works and rests. Frequently, the threads are tied across from one radiating leaf vein to the adjacent one with sufficient tension to pull them slightly towards each other, thus producing a depression beneath the web and providing a retreat for the larva. These nets are of varying extent, but since they are a constant accompanying feature of surface feeding, an attempt was made to determine their significance. That they play some real part in the life of the larvæ is manifested by the fact that while individuals occasionally leave the web-covered tunnels for a certain amount of wandering, they almost invariably return to the original ones or preëmpt others which happen to be empty. Since the leaves of *Nelumbo* rest upon the surface of the water, wave-action, even of a slight degree, often inundates them and, unless protected in some way, the young caterpillars would be constantly exposed to the serious menace of being washed off. A series of experiments showed that the silk webbing constitutes an efficient safeguard against dislodgment by waves. When the larvæ are ensconced under these webs, a vigorous dragging and threshing of the leaf through the water in a manner more severe than the effect of a heavy storm in the protected coves, fails in most cases, to wash them away. Possibly, these webs may serve, also, as a partial protection against certain enemies and excessive light, but according to the evidence at hand, its chief rôle is that of an important adaptation to an ever present feature of the aquatic environment.

Peripheral feeding and accompanying silk formation differ in character from the above-described activities. For varying distances the thin edge of the leaf is folded over and tied by strands of silk which extend from the upturned edge to the upper leaf surface. Varying amounts of silk are used in this activity. Instances were observed where the web was thick and brownish, resembling, to some extent, a sort of cocoon. Often, however, it is a fine, thin, dainty webbing through which the larvæ are plainly visible. Feeding invariably occurs under these webs. Peripheral feeding is a very common habit nearly every infested

leaf showing evidence of it, and occasional leaves are affected only in this way. Sometimes, the entire margin is turned up and tied over. Funnels formed in this fashion are effective retreats and provide efficiently against the larvæ being washed away by wave-action. Sometimes, the turned over edge collects a small quantity of water, and the larvæ may be partly submerged for a time, although no inconvenience seems to be suffered. Since complete filling of the peripheral tunnels with water is possible, the larvæ may, in such an emergency, escape drowning by migration to the petiole junction—a region more elevated, normally, than the margins and more likely to be free from water. The rare occurrence of pupæ in these upturned margins will be mentioned later. Whether the leaf-feeding period is confined to certain instars was not determined. Exuviæ from small larvæ were frequently seen, particularly under the webbings. Field observations on hundreds of larvæ showed that the surface feeders include individuals up to about 14 mm. in length. It thus appears that more than one instar are included in this period.

Petiole Period.—When a certain growth is attained (apparently about 14 mm.), a distinct change in the feeding habit occurs. Surface feeding under webbings is abandoned and the larva begins to tunnel lengthwise into the upper end of the petiole, boring through from the upper surface. By what means the petiole-leaf junction is located with striking exactness is a matter of conjecture. Instances were observed in which wandering larvæ encountered an uninfested leaf, located immediately the petiole junction and began excavation. Sometimes, the larva bores into one of the chief veins of the leaf, tunneling down it to the petiole. Occasional failure to make exact connection with the end of the petiole, resulting merely in a hole through the leaf, is compensated for by constructing an entrance into the side of the petiole just beneath the leaf. A surface net is often constructed over the petiole-leaf junction beneath which the larva works in forming the burrow. When disturbed, it may leave this shelter, wander about over the leaf for a time, later returning to the web or seeking refuge under old nets at the periphery.

The burrow varies somewhat but usually the length is about 23-70 mm. and the diameter a little greater than that of the larva itself. Its entrance is often surrounded by an accumula-

tion of brownish excrement, the burrow being kept comparatively free from such accumulations. Although most, if not all, of the material excavated from the petiole is passed through the digestive tract of the larva, the principal function of the burrow is other than that of a place to feed since the total length does not exceed double that of the full-grown larva—a condition which would not prevail if it were a true feeding burrow, as in the case of *Bellura melanopyga* (Welch, 1914, p. 102) where burrow length increases with occupancy. Not only is the tunnel always short, but also, once formed, it becomes brown inside, and thereafter shows no evidence of further excavation.

After a burrow long enough to contain the whole larva is constructed, the caterpillar turns about and feeds mostly on the upper surface of the leaf just outside the entrance. Larvæ are frequently observed on the upper leaf surface with only one or two posterior body segments remaining in the burrow. A very slight disturbance, however, causes rapid return. Feeding in this position usually results in elongate surface etchings which radiate from the petiole junction. Sometimes the surface within easy reach from the burrow is completely denuded. It thus appears that the chief function of the burrow is to afford a safe retreat from which surface feeding may be accomplished. This accounts for the fact that an examination of a large number of inhabited petioles showed the head of the larva almost invariably directed towards the leaf. As will appear later, the burrow serves also as a pupation chamber.

At no time was more than one larva found in a burrow, the same being true for the pupæ. Occasionally, a nearly mature individual may, for some unknown reason, desert its burrow and wander about over the *Nelumbo* leaves, ultimately constructing a new burrow in some uninfested leaf or else preëmpting an already formed one which it may chance to find unoccupied. Instances were observed where such a wandering larva attempted to enter a burrow already inhabited, whereupon the occupant and the invader engaged in active combat at the entrance, interlocking mandibles, twisting heads, and pushing each other about in a vigorous manner, until the former succeeded in repulsing the latter, or until the invader forced an entrance, displacing the original occupant.

Effect on Food-plant.—In proportion to the numbers of larvæ present, the leaf of the food-plant loses its chlorophyll-

bearing tissue and ultimately shows signs of deterioration. The upper surface shows discoloration, loses its waterproof character, and, in the Sandusky Bay region, usually becomes covered with chironomid (Diptera) larvæ, which form their mud cases all over the exposed surface. Burrow construction partly severs the connection of the leaf with the rootstalk and often results in the ultimate deterioration of the floating part, even in the absence of surface feeding. Since the work of a single larva may lead to leaf deterioration and since it is known that, when present, the buds and seed-capsules are also attacked, it is evident that *P. penitalis* is a serious enemy of *Nelumbo*. The ability of the older larvæ to migrate from leaf to leaf, as described later, also increases their menace to the food-plant.

LOCOMOTION.

Crawling.—Change of position on the food-plant is accomplished by the ordinary methods of crawling. These larvæ are sufficiently active to enable them, where *Nelumbo* leaves are contiguous, to wander widely from the hatching place.

Swimming.—One of the noteworthy adjustments to the aquatic surroundings appears in a well-developed form of surface swimming. Larvæ removed from petiole tunnels and dropped lightly on the water remain supported on the surface. After a few initial squirming movements, active swimming is begun and, as long as nothing interferes with the surface position of the larva, progression is distinctly efficient. Swimming movements consist of an alternate, horizontal, whip-like motion of the posterior half of the body. The sequence of motions is as follows: The posterior end of the body is flexed horizontally on one side into a position in which the caudal end is directed cephalad; then, with a strong, quick sweep, as if released from considerable lateral tension, it returns to the normal position, stopping there for a brief interval; then a similar flexure and return is made on the opposite side. This whip-like motion, first on one side and then on the other, resembles the action of a straight steel spring fixed at one end, bent laterally, suddenly released and stopped at the median position without further vibration; then bent and released on the opposite side. This strong, vigorous return of the posterior end to its normal position constitutes an effective stroke against the water and propels the animal at a goodly rate. So strong

is this lateral beat against the water that it swings the anterior end of the larva in the opposite direction, the succeeding stroke swinging it in the reverse direction, thus making the course described by the head a distinct zig-zag, characterized by abrupt rhythmic changes in the lines of progression. While the swimming activities of this larva resemble in many respects, those of the larva of *Bellura melanopyga* (Welch, 1914, pp. 110-112), there is a distinct difference in the swimming movements, since in the latter they are of the graceful sinuous type and lack entirely the jerky character of the former.

As mentioned above, these larvæ swim in a surface depression. They have an integument which resists wetting and enables them to utilize the surface film, but experiments showed that if these caterpillars break entirely through it they sink slowly, performing in vain the swimming movements described above. They seem to have no ability whatever to swim in water and individuals which become completely submerged ultimately go to the bottom. The fate of such larvæ is not known. It is possible that some may return to the surface by crawling up the stems and petioles of floating and emergent vegetation, since experiments showed that they can withstand continued submergence for at least one and one-half hours.

Sometimes a larva gets inverted on the surface film and has great difficulty in righting itself. The swimming activities are continued, however, in the regular way, progress being made until contact with some plant or floating object enables the caterpillar to regain its normal position.

Ordinarily, larvæ seem somewhat unwilling to leave a supporting leaf and take to water, but when sufficiently disturbed they will voluntarily do so. No doubt new retreats and new feeding surfaces are sought in that way also.

RESPIRATION.

Larval Stages.—As mentioned before, the larva has developed no structural adaptations in connection with its aquatic relations. So far as respiration is concerned, it is a typical air-breather and requires direct exposure to the atmosphere. Throughout the whole larval existence, protection against complete submergence is afforded. Certain features of the food-plant aid materially in accomplishing this end. The exposed surface of the leaf is waterproof, due, according to

Pond (1918, p. 181), to many very delicate hairs which enclose an envelope of air, preventing the water from actually touching the epidermis. Unless the leaf has suffered considerable damage, water thrown upon its upper surface rolls off immediately in silvery masses. Some water is occasionally trapped on the surface by upturned margins, but it also fails to wet the surface, and rolls off at the first opportunity. Furthermore, the region of the petiole junction is normally somewhat higher than the surrounding area, thus producing a sloping surface which easily sheds off any water falling upon it. These two features of the plant are effective not only in keeping the exposed surface above water, but in keeping water away from the burrow. Surface feeding ultimately makes the leaf untenable by the removal of the waterproofing provision and the subsequent wetting and submergence of the surface. Except for short accidental periods of submergence, contact of these larvæ with the water is very slight and offers no obstacle to their obligatory holopneustic respiration. Surface swimming also permits dissemination without interference with the usual respiration activities.

All of the burrows which came under the writer's observation seemed remarkably free from water, in spite of the fact that at least a part of each fully constructed burrow is below the water-level outside. In contrast to the larva of *Bellura melanopyga* which lives in a water filled burrow in the petiole of the yellow waterlily and secures oxygen only when at the top, the larva of *P. penitalis* seems to occupy a burrow which is free of standing water and ordinary spiracular respiration is possible at all times.

Pupal Stage.—Although the exact oxygen demands of the pupa are not known, it is fair to assume that they differ but little from other similar pupæ formed in terrestrial environments since the structural features of the respiratory system are the same. Continued submergence of a pupa removed from its silken covering results fatally, indicating that it also must have a certain protection from water. In connection with the field observations, the writer examined many cocoons, none of which contained water. In fact, the pupa appears to be well provided for in this regard. When the full-grown larva begins preparations for pupation, the first activity is the formation of cream-colored, circular, concavo-convex, very closely

woven silk cap or plug at the upper end of the tunnel, completely closing it. This plug is quite firm in texture and has a thickness of about 0.7–0.8 mm. over most of its area. At the periphery, where it makes contact with the side of the burrow, it is reduced in thickness to an extremely fine membrane, thus providing for the emergence of the imago. The greater part of the burrow is then lined with a strong, silken cocoon, in the upper end of which the pupa is formed. This cocoon is connected with the above-mentioned cap by means of a vertical curtain of silk. The closing plug and complete cocoon seem to be effective in excluding the water and make it possible for this type of pupa to successfully pass its quiescent period in a position slightly below the water line. That this is an aquatic adaptation is indicated by Chittenden's observation (1918, p. 456), that under the terrestrial conditions of raspberry plants a "small amount of silk is used in the construction of these hibernating chambers, and a little is usually to be found at either end"—a description which in no way applies to the same activities of the larva in the *Nelumbo* petiole. The versatility of this larva in becoming adjusted to different surroundings is manifested by the fact that the writer found a few instances of pupation in the rolled up edges of the *Nelumbo* leaf—instances in which a strong, silken cocoon was formed, but no hint of any special features such as the lid-like cap to the petiole burrow. Nothing can be stated at present concerning the nature of the stimuli or sets of stimuli which are operative in impelling the larva to produce an entirely different cocoon for each of the three known pupation conditions, viz., the petiole burrow, the rolled leaf margin, and the stems of certain terrestrial plants. The fact, however, certainly emphasized the special adjustments which have been developed in connection with the aquatic conditions and which have been superimposed upon a persistent ancestral habit.

While it seems evident that the closing cap at the entrance to the tunnel and the underlying, strong, silken cocoon provide a certain protection against drowning, they are not sufficient to safeguard the pupa from another danger—the larvæ of its own species. It often happens that some larva, wandering on the *Nelumbo* leaves, eats away the closing cap of a pupal chamber, penetrates the upper end of the cocoon, destroys the upper portion of the pupa, and ensconces itself in the re-opened

tunnel. Whether the tissues of the pupa were actually used as food or whether the tunnel making instinct of the invading larva caused it to excavate anything which obstructed passage was not determined.

SUMMARY.

1. *Pyrausta penitalis* Grt. (Pyralidæ) occurs abundantly in certain protected situations about Lake Erie in connection with its favorite food plant, *Nelumbo lutea*. It belongs to that extremely limited but interesting, heterogeneous group of Lepidoptera, which has made progress in the development of aquatic adjustments.

2. The life-cycle is imperfectly known. Evidence indicates at least two generations per year. Larvæ and pupæ develop in connection with *Nelumbo,* and eggs, described for the first time, occur on the same plant. Previous writers report relations not only to certain other aquatic plants, but also to two strictly terrestrial ones. Dependable data on the hibernation are lacking.

3. While successfully adjusted to aquatic surroundings, this species has retained the ability to utilize terrestrial conditions, at least to a limited extent. The complete, original, terrestrial organization has apparently been retained also, so that the aquatic adaptations manifested are very largely, if not exclusively, physiological.

4. Surface feeding by young larvæ occurs under silken webs so constructed as to afford adequate protection against dislodgment by wave-action, an ever present menace. The upturned, silk bound margins of the leaf function similarly. Older larvæ construct short petiole tunnels which function only as places for retreat and protection, from which a different type of surface feeding is performed.

5. The older larvæ possess a well-developed, efficient form of surface swimming consisting of an alternate, horizontal, whip-like motion of the posterior portion of the body. They have, however, no ability to swim under the surface and, when completely submerged, sink to the bottom.

6. While an older larva can withstand constant submergence for about one and one-half hours, its typical holopneustic tracheation necessitates access to the atmosphere. Protection from prolonged submergence is provided in part by the water-

proof character of the upper epidermis of the *Nelumbo* leaf and the elevated position of the petiole junction. Surface swimming permits dissemination without serious interference with normal respiration.

7. Pupation occurs in the petiole burrow below the water-level outside and since submergence is fatal, protection is provided not only by the walls of the petiole and the formation of a firm, silken cocoon, but also by the construction of a special closing device—a cream-colored, circular, concavo-convex cap—at the top of the tunnel excluding the water, but providing for the ultimate emergence of the adult. Occasional pupation in the upturned leaf margin is accompanied only by simple cocoon formation, but pupation in terrestrial plants, according to certain writers, appears to be nearly devoid of such provision.

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CHARIESTERUS AND ITS NEOTROPICAL RELATIVES (COREIDÆ HETEROPTERA).

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The Squash-bug family contains an unusually large proportion of insects of bizarre form and possessing strange structures. Expanded or curved tibiæ, swollen and spinose femors, and flattened or clavate antennal joints seem to be the rule rather than the exception.

Among the more modest of the peculiar species are those of the tribe Chariesterini, a group whose members possess a flattened spatulate expansion of the third antennal segment and obliquely truncate, usually spinose, antenniferous tubercles. *Chariesterus antennator*, the most northern member of the tribe, is well known from New Jersey and Iowa to the Gulf of Mexico. A new species from California is described below, whose peculiarly shaped pronotum makes it one of the most remarkable of the Coreidæ.

The tribe is confined to the western hemisphere and includes three genera: Plapigus, Staluptus, and Chariesterus.

Plapigus now contains seven or eight described species, all South American except *circumcinctus* Stal from Mexico. This is a black form, with margins of pronotum, corium, and abdomen flavescent, a distinct callosity behind the eye, tibiæ with testaceous annulus, and expansion of third antennal segment longer than broad. The internal angle of each antenniferous tubercle is acute, and the first segment of the antennæ subclavate; the pronotal margins are entire, and the humeri each armed with a single long slender spine.

Staluptus marginalis Burmeister, according to the original description, is black, with unarmed posterior femora, which are fulvous at base, scarcely dilated third antennal segment, and brown venter and femora. It was described from Mexico.

The species of *Chariesterus*, seven in number, are more widely distributed than other members of the tribe, ranging throughout both continents. In this genus the first antennal segment is parallel-sided, though sometimes slightly broader

toward the tip. The callosity behind the eye, instead of being wanting, as Stal states, is merely usually smooth without acute points, although a few specimens of *C. antennator* from Kansas and Nebraska are at hand in which this tubercle is distinctly muricate.

The following synopsis is based on specimens in the collection of Dr. E. D. Ball, Mr. William J. Gerhard, of Chicago; Mr. H. G. Barber, Mr. Carl J. Drake, the Wisconsin Agricultural Experiment Station, and the Milwaukee Museum, except for *C. armatus* and *C. albiventris*, for whose positions reliance was placed on descriptions. The distribution of each species is indicated in the synopsis for the sake of brevity.

KEY TO THE SPECIES OF *Chariesterus*.

a. Antennæ dilated equally on both sides of third segment.

b. Dilation of third antennal segment only three-tenths as wide as long; legs and antennæ ferrugineous; size 9 x 1.2 mm. (Antilles). *gracilicornis* Stal.

bb. Dilation of third antennal segment at least four-tenths as wide as segment is long; legs and antennæ black; body above brown, below albo-farinaceous; length 11 mm. (Texas and Mexico). *albiventris* Burm.

aa. Antennæ with third segment more angularly dilated on lower side; length over 10 mm.

b. Lateral margins of pronotum armed with distinct tubercles in front of humeri; first antennal segment armed with distinct acute tubercles, larger near base.

c. Pronotum with expanded, elevated lobes at each lateral angle, armed with four or five acute processes of similar size; head with prominent, multispinose tubercle behind each eye. (California) .... *balli* n. sp.

cc. Pronotal angles not expanded, armed with one large tooth preceded by several smaller ones; head with tubercles behind eye smooth or slightly muricate. (United States, east of the Rocky Mountains) .... *antennator* Fabr.

bb. Lateral margins of pronotum unarmed in front of humeral spine; first antennal segment armed with acute tubercles at base only (or none); subtropical or tropical species.

c. Body castaneous, margins and angles of pronotum darker; dilation of third antennal segment not notched; venter refescent; dorsum of abdomen rosaceous; spines of pronotum remarkably long and slender. (Texas to Panama). *cuspidatus* Dist.

cc. Body testaceous, pronotal margins concolorous with or paler than disc; dilation of third antennal segment notched; venter with black spots.

d. Dorsum of abdomen black. (Mexico) .... *moestus* Burm.

dd. Dorsum of abdomen subsanguineous, base and apex black. (South America) .... *armatus* Thunbg.

Chariesterus balli new species. (See Figure).

Head quadrate, armed on the disc with two longitudinal rows of two or three vertical spines each; prominent multispinose tubercles caudodorsad of each eye; antenniferous tubercles spinose at both obtuse lateral and acute mesal angles. Antennæ with first segment

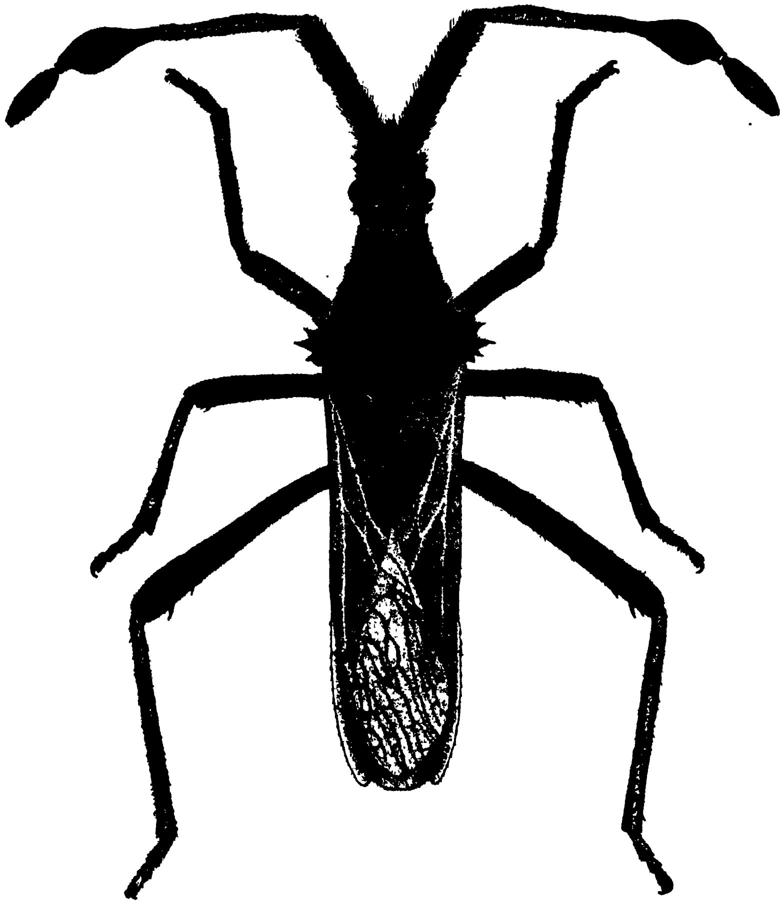


Fig. 1. *Chariesterus balli* n. sp.

strongly triquetrous, lateral carinæ with basal two-thirds armed with numerous acute tubercles, mesal carinæ unarmed except at base; second segment much more slender, shorter, compressed and slightly expanded near the middle; third segment longer than fourth, strongly expanded throughout three-fourths of the length, four-tenths as wide as long. Rostrum scarcely attaining posterior coxæ.

Pronotum more elongate than in *C. antennator*, with each lateral angle elevated, expanded, irregularly armed with three to five large subequal teeth, anterior and posterior lateral margins with several smaller teeth; posterior angles each with flat triangular tooth. Scutellum unarmed. Mesosternum and metasternum, in part, deeply sulcate. Posterior tibiæ shorter than femora. All femora armed with short spines near the apex.

Color black, marked with dark ferrugineous. Head black above, ferrugineous beneath, with a rufescent vitta below each eye, rugose; antenniferous tubercles wide, adjacent, black. Antennæ black, immaculate, except that second segment is ferrugineous; rostrum scarcely attaining posterior coxæ.

Pronotum and scutellum black, pubescent, and very rugose, former with narrow, scarcely perceptible median line paler and slightly sulcate. Corium ferrugineous. Membrane sooty black. Venter and legs dusky ferrugineous.

Cotypes: Two males, captured at Cabazon, California, by Dr. E. D. Ball, and now in his collection.

In the presence of spinose callosities behind the eyes, this species approaches *Plapigus*, while the parallel sided basal antennal segments and the shape of the pronotum indicate *Chariesterus* as the proper genus.

C. antennator is the only species which is likely to be confused with *balli* as all the others possess a single long spine at the humeral angles. The species here described is more slender than *antennator*, a deeper black in color, and with the lateral angles of the pronotum expanded and elevated and armed with four or five large teeth. The tubercle behind the eye is more prominently spinose than in any other species of the genus.

EIGHT NEW "JASSIDS" FROM THE EASTERN UNITED STATES.

Family Cicadellidae (Hemiptera-Homoptera)

J. G. SANDERS and D. M. DELONG, Harrisburg, Pa.

The mountain regions of Pennsylvania and certain less elevated sections of New Jersey, and those portions of Maryland and Virginia between the Chesapeake Bay and the ocean, have received but scant attention from collectors of Homoptera if existing records are dependable. Although relatively little collecting has been done to date, we are able to describe seven new species of distinct interest, while withholding other apparently new forms for more material and better data.

These new species are described from Pennsylvania, one from New Jersey and three from the Maryland-Virginia peninsula; with one exception, all collected by the senior author during the past two years.

Especially interesting and beautiful is the new Phlepsius collected near South Orange, N. J., by Mr. Harry B. Weiss, from "Hercules Club" (*Aralia spinosa*); and also the very distinct and beautifully marked Deltocephalus from grasses on the mountain top near Port Matilda in central Pennsylvania, taken by the senior author.

Platymetopius rubellus n. sp.

Plate XIII, Figs. 1, 2, 3, 4.

Form of *cupreseens* with long pointed vertex, but smaller and with reddish color above and on face. Female, 4.75; male, 4.25.

Vertex longitudinally concave, a little more than twice as long as width between the eyes, margins slightly concave, either side to a very acute apex. Pronotum short and broad. Not quite two-thirds as long as vertex, and more than twice as broad as long. Elytra rather short and broad, broadly rounded at apex. From side view, the front is concave and very acutely angled with vertex. Face long, frons extremely narrow, clypeus constricted just above middle, expanded to rounding apex.

Color: Generally reddish brown, shading toward infuscated apices of elytra. Vertex with median apical line and a line either side extending along margin half way to eyes, and then inward on disc, with faint traces toward median basal portion, pale. Median line deep and black on

basal half. Faint traces of vittæ on pronotum and scutellum; the latter with apex and point at middle of either side, white. Median impressed transverse line, black. Elytra reddish brown with veins darker, supernumerary costal veinlets and vermiculate markings brownish, heavier at apex. Apex with a white band. Areoles few and distinct; two along suture on posterior half of clavus, a row along anterior portion of apical cells and posterior portion of anteapical cells, and one at anterior end of first and second anteapical cells. Front and face uniform reddish brown, often flecked with reddish, and infuscated at apex of vertex, angular line long and very distinct, irregular, dark margin above and below. Eyes red.

Genitalia: Last ventral segment of female with wide sloping to rather prominent angles, then slightly concavely rounded to produced median truncated lobe. Whole segment dark bordered. Male valve broad and roundingly produced to a distinctly angled apex twice as long as preceding segment, which is concavely angled on posterior margin. Plates broad at base, wider than valve, gradually narrowed to sharp tips.

Described from two females and one male from Battle Point, Va., June 22, 1918, and a female from Parksley, Va., June 21, 1918. Collected by the senior author.

Platymetopius collaris n. sp.

Plate XIII, Figs. 5, 6, 7.

A blunt-headed pale species with pronotum and scutellum largely black. Length, Female, 5 mm.; Male, 4.5 mm.

Vertex nearly twice as long as width between the eyes. Posterior angle of head flaring. Pronotum strongly arcuate anteriorly, truncate posteriorly, obliquely cut to outer flaring angles. Elytra broadly rounded at tip. Approximately ten supernumerary veinlets along costal margin.

Color: Vertex dull pale orange, elongated median spot at apex, irregular spot at either side ivory white, between these and extending posteriorly, irregular lines and washing of brown merging and fading posteriorly. Median posterior spot white. Line behind eyes black. Pronotum dull yellow, median two thirds black or dark brown, with pale median line. Scutellum before transverse suture black or dull brown, apex bright yellow. Elytra pale to buff, apical cells clouded and with variable tiny vermiculate markings. Areoles few, white, two in clavus, one at base of each apical cell, and at apex of each anteapical cell. Supernumerary costal and apical veinlets, black or brown. Frons pale shading to dull orange on the cheeks. Pale line extending from tip of apex across eyes in well marked specimens. White "v" below apex indistinct. Venter mottled with gray and brown; pale orange on plates.

Genitalia: Female last ventral segment strongly and evenly produced to a blunt angle. Male valve large, half as large as plates, strongly produced to a blunt angle. Plates evenly narrowed to blunt tips.

Described from four females and one male swept from *Vaccinium* sp. on the mountain at Penfield, Clearfield Co., Pa., August 24, 1918, by the senior author. Type and paratype in authors' collections.

Deltocephalus delector n. sp.

Plate XIII, Figs. 8, 9, 10.

Similar in form and general appearance to *bilineatus* and *marginatus*, but much smaller, really a minute species with distinct markings. Length, male, 3 mm.

Head well produced, with apex distinctly pointed, as long as pronotum, about one-fourth longer on middle than width between the eyes. Pronotum about twice as wide as long, strongly arcuate in front, lateral margins very short, rounded. Elytra with clavus not reticulate and with middle anteapical cell strongly constricted at middle.

Color: Vertex creamy white, with two broad tawny bands extending from base to apex, where they converge and form two black triangular spots either side of white tip, and extend over margin. Behind these in each band a "v" shaped black spot inclined inwardly. A narrow black curved line extends from eye around ocellus on margin toward apex. Median white band distinctly narrowed to apex. Pronotum white, with four longitudinal tawny bands, one behind either eye, and the central two are extensions of the bands on vertex, continuing across scutellum. Elytra tawny with costal, sutural and apical margins and veins, white. A spot in distal portion of inner apical cell, the costal veinlets of the apical and anteapical cells, and a curved band on inner border of the apical white margin, black. Face pale, a spot on the outer margin of loræ, one above antenna, and inner line of antennal pit, brown. Beneath pale yellow, male plates with inner apical third black, but white margined.

Genitalia: Male valve short and broad, with nearly truncate apex. Plates three times length of valve, gradually sloping to broad truncated apices, the outer margins set with coarse spines.

Described from one male specimen swept from grasses by the senior author on the top of mountain between Port Matilda and Phillipsburg, Pa., August 23, 1918. A second specimen was taken, but escaped.

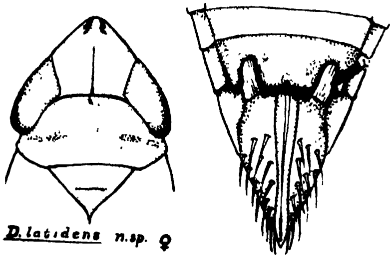
This species is very distinct from others of the *bilineatus* group, on account of its minute size and markings.

Deltocephalus latidens n. sp.

Closely resembling *misellus*, but slightly larger and more robust, with color pattern more vague and with distinct genitalia. Length 3 mm.

Vertex: Flat, slightly longer than width between the eyes, width across eyes almost equaling combined length of vertex and pronotum. Pronotum short, more than twice as broad as long, anterior margin well produced between the eyes. Elytra a little more than twice as long as broad, barely exceeded by abdomen. Face strongly inflated.

Color: Buff irregularly marked with pale orange. Vertex with traces of the four quadrants found in *misellus* usually appearing as a broken, broad, transverse band between anterior margins of the eyes, and two indistinct triangular spots approaching apex, pale orange. Pronotum with traces of six longitudinal pale orange bands. Scutellum pale. Elytra generally darker with pale veins and cells pale orange with few dark markings. Two small spots along suture, one on middle of clavus, one just behind anterior cross vein, posterior margin of inner



D. latidens n. sp. ♀

anteapical and posterior margin of apical cells, brown. Face brown with traces of about eight arcs. Beneath yellow, heavily marked with brown. Ovipositor and broad tooth of last ventral segment in female brown. Male plates brown.

Genitalia: Female last ventral segment more than twice as long as preceding, posterior margin deeply, roundingly incised near lateral margins two-thirds to base leaving a broad central truncated tooth one-half width of entire segment produced beyond the lateral angles, which appear as long, narrow spatulate processes. Male valve broadly triangular, convex, twice as broad as long. Plates short and broad, sloping almost uniformly to broadly rounded apices. Outer margins set with fine white hairs.

Described from eleven females and eight males collected in 1916, at Amery, Wis., August 10; Cameron, Wis., August 7; Merrillam, Wis., August 5; Taylors Falls, Minn., August 16; Trout Lake, Wis., September 9; and Sturgeon Bay, Wis., July 19, 1914, by the authors.

This little species resembles *misellus* so closely in general appearance that the two have been confused. The female genital characters, however, are very distinct.

Phlepsius tenuifrons n. sp.

Plate XIII, Figs. 11, 12, 13, 14.

Form of *ramosus*, but shorter, more robust, head more foliaceous and with distinct genitalia. Length 7 mm.

Vertex well produced, almost entirely concave to sharp, foliaceous apex. More than twice as long as broad, almost twice as long at middle as next the eye. From side view almost entire vertex thin, foliaceous, and upturned. Pronotum short and broad, almost two and one-half times as wide as long. Elytra short and broad, flaring. Face very broad, and rapidly narrowed to base of clypeus. Upper portion very concave or almost angled to thin vertex.

Color: Vertex and pronotum pale with numerous brown irrorations. Median portion of vertex with an irregular brown longitudinal line. Face uniformly irrorate, with pale spot at upper angles of loræ. Elytra milky white, but very heavily marked with broken ramose lines; veins brown. Central portion more closely inscribed with brown, and forming a somewhat obscure saddle across the middle, having a suggestion of paler area toward base of elytra. Beneath uniform brown.

Genitalia: Last ventral segment of female about three and one-half times the length of preceding segment. Gradually rounded either side from half its length to posterior margin, forming rounding lobes instead of prominent angles. Then concavely arcuate to a broad produced median lobe, which is keeled, and narrowly notched at middle. Male valve more than three times as broad as long, roundingly angled at apex. Plates broad at base, then rather suddenly narrowed at about half their length and produced to blunt apices, a little longer than combined width at base. Pygofers very broad at base, convexly produced and sharply incurved toward tips.

Described from a pair collected at Greensburg, Pa. September 3, 1901, and September 2, 1902. Collected by Mr. M. Wirtner.

The short, broad body with sharp foliaceous head well distinguishes this species from its allies.

Phlepsius tinctorius n. sp.

Plate XIII, Figs. 15, 16, 17, 18.

A moderately robust, round-headed species with bright orange markings on vertex and scutellum. Female, 6 mm. and male 5 mm. long.

Vertex about three-fourths of width between eyes, very obtusely angled, almost evenly rounded and parallel margined, with apex narrowly but decidedly inflated before a distinct depression. Pronotum short and broad, truncate posteriorly with distinct flaring lateral angles broader than head. Scutellum transversely concave. Elytra broad with rounded tips. Face broad and flat with clypeus constricted at base and broadly truncate at apex.

Color: Vertex ivory white with small irregular black spot either side of apex; an irregular semicircular black spot above each ocellus vaguely connected by transverse wavy line following depression. Median suture black; on either side a large quadrangular orange spot posteriorly margined with irregular black lines. Pronotum tawny anteriorly, shading to darker, generally marked with vermicular brown lines. Scutellum bright orange with apex and triangular spot midway of lateral margins ivory white. Transverse suture with central spot and median line, and irregular lines extending anteriorly from lateral white spots, black. Elytra milky to smoky with pale tawny areas, uniformly marked with broken irregular lines; tip of clavus, margin of apex, spots of outer apical cell and costal cross-vein, black. Face black with close irregular white or tawny irrorations. Antennæ black, with pits and apices of basal segments white. Venter generally black or dark brown.

Genitalia: Female segment longer than preceding and smoothly truncate. Male valve half as long as preceding segment, broadly and bluntly angled; plates long triangular, evenly tapering to posterior third with long curved terete tips.

Described from eight females and one male collected by H. B. Weiss from "*Aralia spinosa*" at Irvington and South Orange, Essex Co., New Jersey, July 23 and August 1. Type and paratypes in authors' collections, and in New Jersey State Museum Collection.

Chlorotettix productus n. sp.

Plate XIII, Figs. 19, 20.

Small wedge-shaped species with well rounded vertex, a little more produced than in *viridius*. Female, length 5 mm.

Vertex roundingly produced, not angled, almost parallel margined; slightly longer on middle than next the eye, about twice as wide as long. Pronotum strongly and convexly produced, truncated posteriorly, lateral margins well rounded. Front broad, inflated.

Color: Dull yellowish green without definite markings. Vertex and frons shading to buff. Elytra greenish, subhyaline, distinctly shiny. Paler below, tip of ovipositor and bristles, yellowish.

Genitalia: Female last ventral segment one-third longer than preceding and longitudinally striated. Lateral angles roundingly produced. Posterior margin concavely sinuate to produced median third, slightly notched at middle. Pygofers with heavy bristles on posterior half.

The produced last ventral female segment distinguishes this species from others of the genus.

Described from three female specimens swept from a low shrub at Battle Point, Virginia, June 23, 1918, by the senior author. Type and paratypes in authors' collections.

Chlorotettix fumidus n. sp.

Plate XIII, Figs. 21, 22, 23.

Resembling *tergatus* in size and color, but narrower, with head well produced and angled. Length, female, 8 mm.; male, 7.5 mm.

Vertex produced, distinctly angled; one-half longer on middle than next the eye, and about twice as wide as long. Pronotum very convex anteriorly and almost truncate posteriorly, length one-half the width. Second apical cell much narrower than in *tergatus*.

Color of vertex dull pale orange; face pale straw-yellow. Pronotum and scutellum smoky green, elytra dark smoky. Body above black; beneath pale yellow.

Genitalia: Last ventral segment of female about one-half longer than preceding; obliquely produced to outer angle, with posterior margin truncate or slightly concave to broad. deep median notch two-thirds distance to base. Male valve triangular, as wide as preceding segment, apex rounded and posterior margins slightly sinuate. Plate short and broad, convexly rounded to acute appressed tips.

Described from three female and two male specimens. Type specimen, female, collected at Mt. Alto, Pa., August 24, 1918, by T. L. Guyton. Two females from Moscow, Tenn., collected by the junior author, June 23, 1915; one male from Paris, Tenn., June 26, 1915, and one male from Speeceville, Pa., July 22, 1917, by the senior author. Type and paratypes in authors' collections.

EXPLANATION OF PLATE XIII.

1.—*Platymetopius rubellus* n. sp., head (dorsal view).
2.—head (side view). 3.—♂ genitalia. 4.—♀ genitalia.

5.—*Platymetopius collaris* n. sp., head.
6.—♂ genitalia. 7.—♀ genitalia.

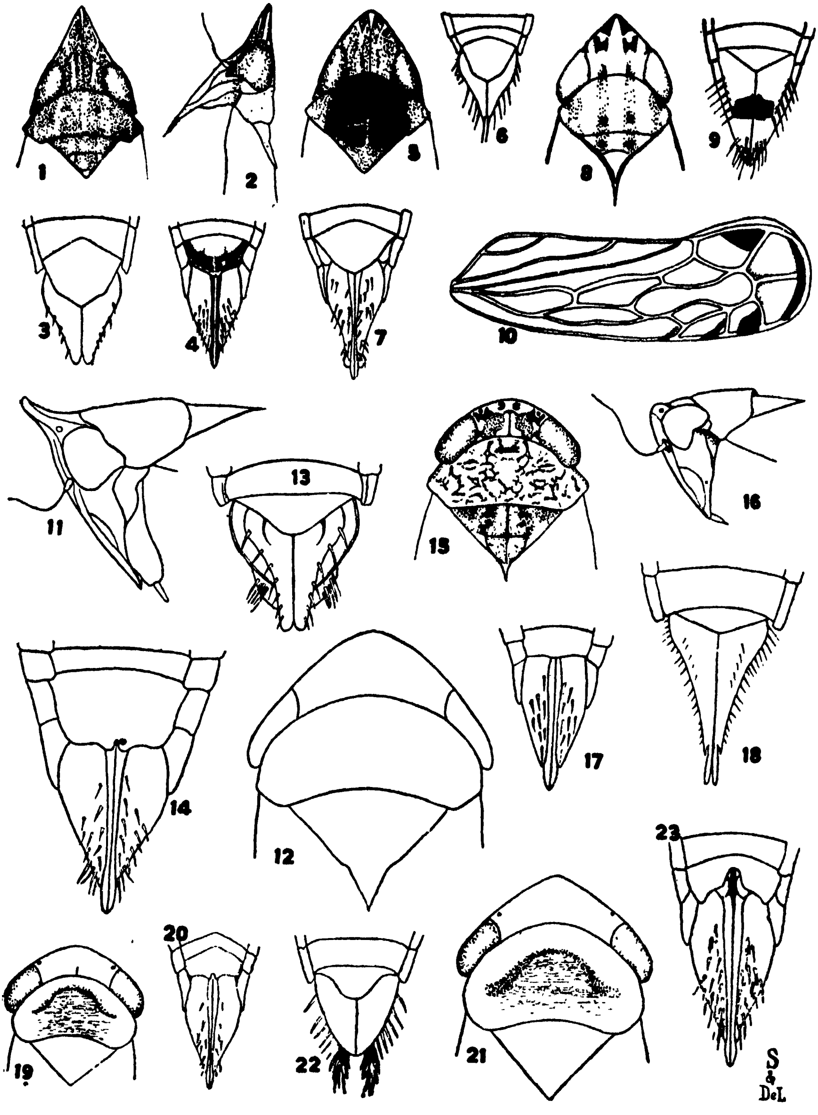
8.—*Deltocephalus delector* n. sp., head.
9.—♂ genitalia. 10—elytron

11.—*Phlepsius tenuifrons* n. sp., head (side view).
12.—head (dorsal view.. 13.—♂ genitalia. 14.—♀ genitalia.

15.—*Phlepsius tinctorius* n. sp., head (dorsal view).
16.—head (side view). 17.—♀ genitalia. 18.—♂ genitalia.

19.– *Chlorotettix productus* n. sp., head. 20.—♀ genitalia.

21.—*Chlorotettix fumidus* n. sp., head.
22.—♂ genitalia. 23.—♀ genitalia.



Sanders and DeLong.

NEW WESTERN SPIDERS

By Ralph V. Chamberlin.

Most of the new forms of spiders described below were found in collections made by the writer in Utah in the latter part of August and the early part of September, 1917. The collections were made on Chalk Creek in the Uintah Mts., at elevations of from 7,300 to 10,000 ft. and at and near Fillmore, Millard Co. In addition to the spiders from Utah, a number of new forms from other localities noted while identifying the collections mentioned are here described.

DICTYNIDÆ.

Amaurobius utahensis sp. nov.

Male—Carapace, sternum, labium, endites and legs yellow, without any reddish tinge, the legs unmarked. Abdomen blackish, the anterior middle region of dorsum obscure yellow, the posterior half with dark marks which are, excepting the first ones, only vaguely separated from each other. Anterior row of eyes procurved; medians close together, but more than their diameter from the laterals. Posterior eyes much smaller than the anterior ones, the medians slightly smaller than the laterals, about twice their diameter apart and about twice as far from the laterals. Area of median eyes rectangular, being as wide behind as in front, longer than wide. Distal joints of palpus heavier than in *nevadensis*. Tibial apophyses very similar to those of the species mentioned; but the exterior one distally less uncate, the median one basally broader and more narrowed distad, and the mesal one obviously broader and shorter and differing particularly in being united with or carried forward on a common base with the median one much farther, the ridge uniting the two in *nevadensis* being slight or obsolete.

Length, 11.5 mm. Length of cephalothorax, 6.1 mm. Length of tib. + pat. I, 6.4 mm.; of tib. + pat. IV, 6.7 mm.

Type—M. C. Z. 414, Utah: Fillmore.

This species is nearest *A. nevadensis* Simon. It is a more robust species, wholly lacking the reddish cast characteristic of *nevadensis*. It differs chiefly otherwise in the details of the male palpus as indicated above and also presents minor differences in the eyes.

Amaurobius nomeus sp. nov.

Female—Carapace and sternum light yellowish brown, becoming blackish in anterior portion of pars cephalica. Legs paler. Labium and endites chestnut, pale across tips. Cheliceræ black. Abdomen above greyish yellow, with a narrow, median longitudinal dark mark extending well caudad of the middle, where its point ends at the angle of a transverse chevron line, which is followed by several others; in front of the first chevron there are two or more lines running obliquely caudoectad from the edge of the median mark. Sides of abdomen darkened by numerous spots and streaks as is also the venter on which they tend to form two longitudinal stripes and a narrower median line separated by clear spaces. Anterior row of eyes procurved; median eyes smaller than the laterals, their radius or a little more apart, and a little more than their diameter from the laterals. Posterior row of eyes longer than the anterior; eyes smaller than the anteriors; the medians smaller than the laterals. Median eyes forming a trapezium wider behind than in front in ratio of about 25:20 and wider behind than long, the length scarcely exceeding the anterior width. Tibia I armed beneath with two pairs of spines, none being present at distal end; tibia with a single spine at distal end in addition to the two pairs. Epigynum smooth, median interval narrow, the process ventrally rounded. See Plate XIV, Fig. 1.

Male palpus is shown in Plate XIV, Fig. 2.

Length 11.2 mm. Length of cephalothorax, 5 mm. Length of tib. + pat. I, 4.1 mm.; of tib. + pat. IV, 4.3 mm.

Type—M. C. Z. 416.

Utah: Uintah Mts., 10,000 ft.

This species has resemblance to *A. benneti B* and *A. pictus S.* When placed alongside of these species the cephalothorax is seen to be obviously more narrowed at the anterior end. It is distinct in the details of epigynum and eye arrangement.

Dictyna uintana sp. nov.

Female—Carapace fuscous or nearly black, clothed with white hairs. Sternum blackish. Legs yellow, distinctly annulate with black, the annuli of tibia and metatarsus deepest, the femora with a submedian and a distal annulus, patella with annulus at distal end, tibia with an annulus at each end and metatarsus with an annulus at distal end and a broader, but less distinct proximal one. Abdomen testaceous; at base above with a long triangular to hour-glass shaped dark brown mark followed by a number of chevron marks, of which the first is connected by its apex with the basal mark; caudal end of dorsum typically covered by a solid black area; sides of abdomen darkened above by streaks and spots of brown; venter commonly showing an often vague longitudinal median dark band. Anterior row of eyes

straight; median eyes decidedly smaller than laterals, scarcely their diameter from the laterals, one half their diameter from each other and about the same distance, or slightly farther, from the lower edge of clypeus. Posterior row of eyes straight; median eyes obviously larger than the anterior medians, once and a quarter or scarcely more their diameter apart and near the same distance from the laterals; posterior laterals equal to the anterior laterals. Area of median eyes a little wider behind than in front. In front view the inner edges of the cheliceræ are obviously curved ectad over most of their length, as shown in Plate XIV, Fig. 3; Epigynum as shown in Plate XIV, Fig. 4.

Male—Cheliceræ with a low rounded tubercle or tooth at exterior angle of base. Palpus with tibial apophysis short, but rather stout. Cf. Plate XIV, Fig. 5.

Type—M. C. Z. 405. XIV, Utah: Uintah Mts.; Chalk Creek, elevation, 7,500 ft. Webs on boughs of pine trees.

Resembles *sublata*. The latter, among other differences, has the eyes of the anterior row obviously more nearly equidistant and the form of the epigynum different.

Dictyna coloradensis sp. nov.

Female—This species has to some extent been identified with *D. arundinaceoides* Keys, but is not that species, which seems to be really the *D. sublata* of Hentz. Carapace and sternum fuscous. Legs yellowish or pale brown, without distinct markings or often with femora darkened and tibiæ and metatarsi annulate at distal end and with less distinct annuli toward proximal end. Abdomen above with the usual triangular mark at base; behind this two rows of annular markings more or less connected by dark lines or chevrons between them. Anterior row of eyes straight; median eyes a little smaller, separated by about their diameter, very slightly closer to laterals. Clypeus rather low, the height being between once and a half and twice the diameter of an anterior median eye.

Posterior row of eyes straight; eyes equidistant. Area of median eyes wider behind than in front. Epigynum shown in Plate XIV, Fig. 7.

Male—Darker than the female. Femora darkened and a distinct dark annulus at distal end of tibiæ and metatarsi and a less distinct one proximally, or legs sometimes lacking these dark markings. Clypeus much higher than in the female and median eyes smaller. Cheliceræ dentate at base toward ectal side as shown in Plate XIV, Fig. 6. Process of tibia of palpus stout, of moderate length, distally bi-dentate. Cf. Plate XIV, Fig. 8.

Length of female up to 3.5 mm.

Type—M. C. Z. 395. Colorado: Colorado Springs (R. V. Chamberlin, coll.); Eldora; Pagosa Springs; Fort Collins, etc. New Mexico: Beulah; Mesilla.

Dictyna bellans sp. nov.

Female—Carapace and sternum pale brown to yellow, sometimes of slight reddish cast. Legs yellow. Abdomen grey, under the lens showing the usual network of fine dark lines; a triangular dark spot on base above followed by two or three pairs of large dark dots which may be connected on each side. Venter immaculate grey. Anterior median eyes a little smaller than the laterals. Posterior row of eyes recurved. Area of median eyes as wide in front as behind. Epigynum as shown in Plate XV, Fig. 4.

Male—The abdomen in the types is either wholly immaculate or shows the dorsal markings only vaguely. The basal tibial process of the male palpus is erect, moderately long, and shows but a single distinct tooth or point at distal end. Toward anterior end of tibia above is a second much shorter process or tooth as shown in Plate XV, Fig. 5. Process at base of chelicera long and curved. See Plate XV, Fig. 3.

Length of female up to 2.8 mm.

Type—M. C. Z. 403. Mississippi (R. V. Chamberlin.)

Dictyna sociella sp. nov.

Female—Carapace fuscous, the pars cephalica a little paler. Sternum dusky brown or fuscous. Legs yellow, some darker annuli faintly traceable. Abdomen on basal half of dorsum with two connected triangular dark marks and the usual line of more or less connected dark spots on each side behind, elsewhere the usual fine network of dark lines over a light ground. Anterior eyes nearly equidistant, the median eyes only slightly smaller than the laterals. Posterior eyes also nearly equidistant. Area of median eyes a little wider behind than in front. Epigynum, Plate XV, Fig. 8.

Length, 3.2 mm.

Type—M. C. Z. 412. Washington: Wawawai.

Distinguished particularly by the form of the epigynum and by the eye relations.

Dictyna insolens sp. nov.

Male—Carapace and sternum fuscous. Legs yellow, somewhat dusky, the tibiæ and more especially the metatarsi obscurely annulate. The narrow annulus at distal end of metatarsi most distinct. Abdomen dorsally with a black triangular mark at base followed by a pair of dark spots and then two heavy chevrons behind which is a clear area; sides darkened; venter light. Anterior median eyes smaller than the laterals. Posterior eyes equidistant. Area of median eyes a little wider behind than in front. Process of tibia of male palpus very short and proportionately wide with the anterior tooth much the larger. See further Plate XV, Fig. 6. Chelicera with basal tooth slight, rounded.

Length, 2 mm.

Type—M. C. Z. 409. Washington: Olympia.

Dictyna vincens sp. nov.

Female—Carapace and sternum fuscous. Legs yellow to pale brown. Abdomen above at base with a black mark having caudal end excised in an obtuse re-entrant angle and on each side the usual dark lines radiating from its angles and edges; behind the middle first a pair of widely separated dark spots and then typically two exceptionally thick chevrons, which sometimes give the caudal end the appearance of being almost solid black; sides often darkened; venter either uniform or with a dusky or blackish band over its length, or with a black area only in front of spinnerets. Anterior median eyes essentially equaling the laterals, their diameter apart, closer to the laterals. Posterior eyes equidistant. Area of median eyes as wide in front as behind. Epigynum, Plate XV, Fig. 1.

Male—In what is regarded as the male of this species the coloration is similar to that of the female though the general appearance of the abdomen is darker and more uniform with the markings less distinct and sometimes almost obliterated. The palpus is shown in Plate XV, Fig. 2.

Length of female, 3.25 mm.; of male, 2.5 mm.

Type—M. C. Z. 410. Washington: Olympia.

Dictyna olympiana sp. nov.

Male—This small form has the usual general coloration; the carapace and sternum dusky brown; legs yellow; abdomen at base above with a median dark line expanding into a triangular spot in front of middle, this followed behind by the usual pairs of longitudinally connected spots, the sides also dark. Anterior median eyes smaller than the laterals and than the posterior medians. Area of median eyes clearly wider behind than in front. The species is readily characterized by the large size of the tarsus of the palpus and the form of the particularly large palpal organ. The process of tibia is small, erect, and bidentate, the teeth being equal. See further Plate XV, Fig. 7. Chelicera rather small, slightly bulging at base in front, but without a true process or tooth.

Length, 1.7 mm.

Type—M. C. Z. 408. Washington: Olympia.

Dictynoides gen. nov.

Pars cephalica broad, low, not gibbous. Anterior row of eyes straight, the eyes equal or the medians smaller. Lateral eyes on each side subcontiguous. Posterior row of eyes straight, eyes equidistant or the median farther apart than from the laterals. Area of median eyes quadrate or trapeziform, wider than long. Clypeus with height much exceeding the diameter of the anterior eyes. Cheliceræ long, with lower margin armed with two or three teeth. Labium broad, moderately narrowed distad, extending a little beyond middle of endites. Endites oblique, inclined. Cribellum entire. Legs without spines.

Genotype—*D. arizonensis* sp. nov.

Includes also *Lathys trivittata* Bks., known from New Mexico. The genus differs from Lathys in its inclined endites and much higher clypeus, and from Dictyna in its shorter labium and lower, less convex, pars cephalica.

Dictynoides arizonensis sp. nov.

Female—Carapace rufous brown along each side, the median and a marginal stripe on each side paler; along the pars cephalica and converging caudad are three bands of white hair as in trivittata. Sternum dusky yellow to nearly black. Legs yellow, not annulate. Abdomen pale with some darker spots above; clothed with white hair. Anterior row of eyes straight; eyes equidistant or the medians a little farther from each other than from the laterals; the medians smaller than the laterals. Height of clypeus more than twice the diameter of the anterior median eyes, slanting conspicuously forward from above below. Posterior row of eyes straight or nearly so, eyes equal in size and obviously larger than the anterior median, nearly equidistant, the medians slightly farther apart than from the laterals. Area of median eyes wider behind than long (cir. 12:10) and obviously wider behind than in front, the anterior width being equal to the length. Epigynum as shown in Plate XVI, Fig. 1.

Length, 5 mm. Length of tib. + pat. I, 2.8 mm.; tib. + pat. IV, 1.8 mm.

Type—M. C. Z. 393. Arizona: Huachuca Mts.; Miller Canyon, elevation 5,600 ft. (W. M. Wheeler, 17th Nov., 1910).

ULOBORIDÆ.

Uloborus utahensis sp. nov.

The types of this species, which are not quite fully mature females, seem readily distinguishable by pronounced differences in coloration in connection with structural features. Carapace and sternum black or nearly so, with the usual clothing of white hair. Leg I with femur and patella entirely black, the tibia black, excepting a narrow ring at proximal end, and the metatarsus with a narrow black annulus at each end and two broader ones in the intervening region, the tarsus dark except at ends. Leg II has the femur black throughout, with no narrow pale median annulus; metatarsus with two broad dark annuli or these indistinctly separated, each close to its end of the joint. Femur III black, with one pale annulus distad of middle and one less distinct at proximal end; tibia with a pale annulus at proximal end and a sub-median one; metatarsus pale at proximal end and at middle. Leg IV with femus having two pale annuli of which the more proximal is commonly incomplete below; the other joints as in leg III. The abdomen somewhat elongated, without any distinct humps above; dark, being covered with a dense network of black lines, a brown median longi-

tudinal black stripe above at base; venter blackish with a pale longitudinal line on each side. Posterior row of eyes rather strongly recurved, the median eyes much farther from each other than from the laterals. Area of median eyes longer than wide, a little narrower in front than behind.

Length, 3 mm. Length of cephalothorax, 1 mm. Length of tib. + pat. I, 1.54 mm.; of tib. + pat. IV, 1.13 mm.

Type—M. C. Z. 476. Utah: Fillmore.

DRASSIDÆ.

Drassodes robinsoni sp. nov.

Female—Carapace and sternum yellow of slightly reddish-brown cast. Legs yellow. Labium and endites brown, pale at tips. Abdomen yellowish grey, dusky on sides, especially posteriorly; a weakly indicated hestate outline from base to middle, with very faintly indicated chevron lines traceable behind it. Cheliceræ deep brown. Lower margin of furrow of chelicera armed with two rather small teeth. Anterior row of eyes procurved; the eyes subequal or the medians a little the smaller; median eyes nearly their diameter apart, half as far from the laterals. Posterior row of eyes procurved; median eyes their larger radius apart, between once and a half their diameter apart from the laterals. Tibiæ I and II armed beneath with a single spine between middle and distal end. Posterior tibiæ armed with a spine above at base and with one distad of middle. Epigynum as shown in Plate XVI, Fig. 2.

Length, 9.6 mm. Length of cephalothorax, 3.9 mm. Length of tib + pat. I, 3.9 mm.; of tib. + pat. IV, 3.3 mm.

Type—M. C. Z. 418. Utah: Fillmore.

Dedicated to Mr. Joseph Robinson, of Fillmore, who gave enthusiastic assistance in the collecting of spiders in that region.

Drassodes gosiutus sp. nov.

Male—This species belongs in the *lapidosus* group. It is characterized among North American species in wholly lacking a tibial apophysis on the male palpus and in having the lower margin of the furrow of the chelicera bearing but a single, noduliform tooth. Carapace, sternum and legs yellow, the abdomen light grey or whitish. Anterior row of eyes procurved; median eyes larger than the laterals, about three-fourths, or somewhat more, their diameter apart and their radius from the laterals. Posterior row of eyes much longer than the anterior, obviously procurved; median eyes much larger than the laterals, subelliptic, somewhat angulate, only about their lesser radius apart, more than their long diameter from the laterals. Tibiæ I and II armed beneath distad of the middle with a single spine. Metatarsi I and II armed beneath its base with a single spine. The claw of the chelicera

long and somewhat sinuous. Upper margin of furrow of chelicera armed with three teeth of which the most proximal is nearer the median than is the most distal. Tarsus and bulb of male palpus proportionately small and slender; the tarsus bearing two long spines on its ventral face distad of the bulb. See Plate XVI, Fig. 3.

Length, 7.5 mm. Length of cephalothorax, 3.5 mm. Length of tib. + pat. I, 4 mm.; of tib. + pat. IV, 4 mm.

Type—M. C. Z. 389. Utah: Fillmore.

Drassodes melius sp. nov.

Female—Carapace and sternum pale testaceous, the legs more yellowish. Abdomen above dark brownish grey with a somewhat obscure, darker, median longitudinal stripe with vaguely indicated chevron marks behind, the venter somewhat lighter, much so in front of the epigastric furrow; the epigynum dark chestnut. Anterior row of eyes procurved; eyes subequal; median eyes nearly their diameter apart, a little less than their radius from the lateral. Posterior row of eyes straight; eyes smaller than the anterior ones and the medians slightly smaller than the laterals; median eyes a little less than once and a half their diameter apart and a little more than that distance from the laterals. Area of median eyes quadrate, as wide in front as behind. Lower margin of furrow of chelicera armed with two stout teeth. Tibiæ I and II each armed beneath with a single submedian spine. Posterior tibiæ not armed above at base. Epigynum as shown in Plate XVI, Fig. 5.

Male—Palpal organ as shown in Plate XVI, Fig. 4.

Length of female, 11 mm. Length of cephalothorax, 4.1 mm. Length of tib. pat. I, 4 mm.; of tib. pat. IV, 5 mm.

Length of male, 8.8 mm. Length of cephalothorax, 3.7 mm. Length of tib. + pat. I, 5 mm.; of tib. + pat. IV, also 5 mm.

Type—M. C. Z. 419. Utah: Uintah Mts., 10,000 ft.

Herpyllus oabus sp. nov.

Male—Carapace, legs and sternum yellow, without markings. Endites whitish across tips. Abdomen yellowish grey, darker above than beneath, without definite markings. Anterior row of eyes procurved; eyes about their diameter from edge of clypeus; median eyes larger than the laterals, scarcely their radius apart, closer to the laterals. Posterior row of eyes slightly procurved; eyes somewhat smaller than the anterior, the medians smaller than the laterals; median eyes nearly once and a half their diameter apart, closer to the laterals. Tibia I armed beneath with two pairs of spines, one pair basal and one submedian. Tibia II armed beneath with five spines, there being an unpaired spine at base, a pair at middle, and a pair of smaller ones at the distal end. Metatarsi I and II each armed beneath with two pairs of spines. Male palpus as shown in Plate XVI, Fig. 6.

Length, 4.6 mm. Length of cephalothorax, 2.4 mm. Length of tib. + pat. I, 2.4 mm.; of tib. + pat. IV, 2.8 mm.

Type—M. C. Z. 386. Utah: Fillmore.

Zelotes tuobus sp. nov.

Female—Carapace black, in part of a dull chestnut cast. Sternum dense black. Legs black, of slightly brownish cast, excepting the tarsi, which are paler. Endites blackish, paler across distal end. Abdomen black or nearly so, a little paler, greyish black, beneath. Anterior row of eyes strongly procurved, the median eyes lying above the line connecting the centers of the laterals; laterals fully twice the diameter of the medians; the medians about their diameter apart, but very close to the laterals. Posterior row of eyes straight; median eyes a little smaller than the laterals, about three-fourths their diameter apart, a little farther from the laterals. Quadrangle of median eyes obviously longer than wide, slightly wider behind than in front. Tibiæ I and II unarmed beneath. Metatarsi I and II armed beneath at base with one pair of spines. Posterior tibiæ not armed above. Epigynum as shown in Plate XVI, Fig. 7.

Length, 9.5 mm. Length of cephalothorax, 3.9 mm. Length of tib. + pat. I, 3.6 mm.; of tib. + pat. IV, 4.2 mm.

Type—M. C. Z. 387. Utah: Fillmore.

This species is very close to *Z. ater* (Hentz). The epigynum is proportionately longer with the anterior pockets obviously closer together and the inner lateral elevated edges also less widely separated.

PHOLCIDÆ.

Psilochorus utahensis sp. nov.

Cephalothorax pale yellow. Legs darker yellow. Abdomen grey, with some darker mottling. Posterior row of eyes straight; median eyes nearly once and a half their diameter apart, contiguous with lateral eyes, about their radius from anterior laterals and three-fourths their diameter from anterior medians. Characterized by having femur I in the female shorter than femur IV, the reverse of the condition in the male. Process of chelicera in male large, arising at base and projecting prominently forward and downward, at tip acutely pointed and curving mesoventrad, (Plate XVII, Fig. 1). The species is characterized particularly by the details of structure of the male palpus. In this the femur is slender from base to a little beyond middle, with the distal end strongly enlarged; at base on ectal side an elongate tubercle or swelling and a small process or tubercle from ventral edge at distal end. The exterior process of the palpal organ straight, narrowest at middle, and differing from that of *pulullus* and *californiæ* in appearing bifid at distal end. (Plate XVII, Fig. 2).

Length of female, to 4.4 mm. Length of tib. + pat. L, 4.75 mm.; of tib. + pat. IV, 5 mm.

Type—M. C. Z. 451. Utah: Clear Lake; Fillmore; Fillmore Canyon; Pine Canyon; et cetera.

LINYPHIIDAE.

Linyphia latescens sp. nov.

Female—Dusky yellow, darker at margin, the eyes edged with black. Legs also yellow, the femora and patellæ dusky, the tibiæ with a broad annulus proximad of middle and a narrower, deeper one at distal end, the metatarsi also similarly annulate. Sternum blackish. Abdomen grey, with abdomen crossed, excepting at anterior end, by a series of heavy blackish chevron marks connected by a more obscure median longitudinal dark line; sides dusky. Posterior row of eyes straight, the median eyes a little less than their diameter from the laterals, nearer to each other. Anterior row of eyes a little procurved, the medians much smaller than the laterals, less than their diameter apart, obviously more than their diameter from the laterals. Area of median eyes as long as wide or very slightly longer.

Male—Coloration as in female. Palpus as shown in Plate XVII, Fig. 3. Embolus coiled in a circle at distal end.

Length of female, 2.2 mm. Length of cephalothorax, .9 mm. Length of tib. + pat. I, 1.36 mm.; of tib. + pat. IV, 1.25 mm.

Type—M. C. Z. 429. Utah: Uintah Mts.; Chalk Creek.

Linyphia orinoma sp. nov.

Female—Carapace, legs, chelicerae and endites yellow, without markings. Sternum and labium dusky or blackish, the color of the former appearing denser toward edges. Abdomen greyish yellow, with a few scattered small silvery dots and sometimes a dusky area at base of spinnerets on each side and occasionally also a dusky area in front of this; with no trace of dorsal dark markings, such as occur in *insignis*. Posterior row of eyes straight, the median eyes slightly nearer to each other than to the laterals, separated by their diameter or a little more. Anterior row of eyes straight; median eyes smaller than the laterals, their radius or less apart, nearly their diameter from the laterals. The epigynum projects in a straight, finger-like process, which is a little clavately expanded distad and is rounded at the end, where it has openings closer together than those of *insignis;* the dorsal surface just proximad of the tip having a deep lunate impression with concavity caudad, the form and position of this impression differing strongly from that of *insignis*. (Plate XVII, Fig. 4).

Length, 3.25 mm. Length of tib. + pat. I, 2.2 mm.

Type—M. C. Z. 427. Utah: Millard County; Clear Lake. Also a not fully matured specimen in Uintah Mts. on Chalk Creek.

Evidently close to *insignis* from which distinguished by the uniform presence of silver-colored spots on the abdomen, with absence of dorsal markings and particularly by the detailed structure of the epigynum.

Bathyphantes fillmoranus sp. nov.

Female—Carapace and sternum dusky yellow, the sternum the darker. Legs yellow. Abdomen above white, broken into closely arranged spots, a median dorsal line from which oblique lines on each side extend in an anastomosis. Venter greyish, with a few scattered small white dots. Posterior row of eyes straight; median eyes less than their radius apart, and about three-fourths their diameter from the laterals. Anterior row of eyes straight; medians smaller than laterals, less than their radius apart, more than their radius but less than their diameter from the laterals. Clypeus much narrower than length of area of median eyes. Upper margin of furrow of chelicera with six teeth, the lower margin with five much smaller ones. For epigynum see Plate XVII, Fig. 5.

Length, 2.2 mm. Length of cephalothorax, 1 mm. Length of tib. + pat. I, 1.25 mm.; of tib. + pat. IV, 1.13 mm.

Type—M. C. Z. 425. Utah: Fillmore Canyon.

Grammonota orites sp. nov.

Male—Cerapace dusky yellow-grey, with the eyes edged with black. Sternum and labium dusky over yellowish to nearly solid black. Legs, endites and cheliceræ yellow. Abdomen dusky over a paler background to nearly solid black; dorsum without definite markings. Posterior row of eyes slightly procurved, eyes equidistant, separated by nearly their diameter. Anterior row of eyes straight; median eyes much smaller than the laterals, hardly their diameter from the latter, nearer to each other. Clypeus a little wider than the eye area. Pars cephalica rising behind eye area as usual; crossed by a single median longitudinal series of setæ, which are longest just caudad of the eyes. Upper margin of furrow of chelicera with four or five large teeth, the lower margin with several much smaller ones. Tibial apophysis of palpus large, plate-like, with mesal side produced forward as a one-pointed process which curves ectad at tip. See Plate XVII, Fig. 8.

Female—The epigynum is shown in Plate XVII, Fig. 7.

Length, 2.3 mm.

Type—M. C. Z. 440. Utah: Uintah Mts.; Chalk Creek, 7,500 ft.

Distinguished from other North American species by the form of the tibial process of the male palpus and the structure of the palpal organ.

Grammonota simplex sp. nov.

Male—A smaller and paler species than the preceding one from which it is at once distinguishable in lacking the conspicuous tibial apophysis of the palpus. Carapace dusky yellow with the darker shield-shaped area at posterior end of pars cephalica; the sternum darker. Legs yellow. Abdomen blackish to grey. Posterior row of eyes straight, the eyes equidistant. Anterior row of eyes straight, eyes close together, sometimes appearing nearly equidistant, but most commonly with the medians nearer to each other than to the laterals; the medians smaller than the laterals. Tibia of palpus wholly lacking an apophysis at distal end above. See Plate XVIII, Fig. 1.

Female—Epigynum as shown in Plate XVIII, Fig. 2.

Length of male, 2 mm. Length of cephalothorax, .9 mm. Length of tib. + pat. I, .8 mm.

Type—M. C. Z. 432. Utah: Uintah Mts.; Chalk Creek, 7,300 ft.

Grammonota obesior sp. nov.

Female—Carapace comparatively low, yellowish of slightly orange cast with a black marginal line on each side; eyes edged with black. Sternum dusky. Abdomen blackish, under the lens showing numerous minute light dots and some light lines at sides of dorsum. Eyes as in the preceding species. Abdomen proportionately broader and higher than in the preceding forms. Distinguishable by the characteristic form of the epigynum which is represented in Plate XVII, Fig. 6.

Length, .2 mm. Length of cephalothorax, .8 mm.; width, .66 mm. Length of tib. + pat. I, .8 mm.; of tib. + pat. IV, .9 mm.

Type—M. C. Z. 437. Utah: Uintah Mts.; Chalk Creek.

Grammonota fratrella sp. nov.

Female—A smaller species readily distinguishable by the form of the epigynum. The carapace is slightly dusky over a dilute yellowish background, the eyes and lateral borders narrowly edged with black. Sternum very dusky, nearly black. Legs pale yellow. Abdomen black or nearly so, without definite markings. Posterior row of eyes straight; median eyes their diameter apart, slightly nearer to the lateral. Anterior row of eyes a little recurved; median eyes much smaller than the laterals, scarcely their radius apart, their diameter from the laterals. Clypeus narrower than eye area. Epigynum as shown in Plate XVIII, Fig. 3.

Length, 1.64 mm. Length of cephalothorax, .76 mm. Length of tib. + pat. IV., .9 mm.

Type—M. C. Z. 443. Utah: Uintah Mts., 8,500 ft.

Cornicularia monticolens sp. nov.

Female—Carapace dusky yellow to dusky chestnut, the lateral margins solid black; eyes edged with black. Sternum more blackish than carapace. Labium and endites also dusky. Legs yellow, often dusky, with distal ends of coxæ beneath often narrowly lined with black. Abdomen blackish, without definite markings. Posterior row of eyes straight or slightly recurved, the median eyes farther from each other than from the laterals. Nearly twice their diameter apart. Anterior row of eyes straight; median eyes much smaller than laterals, nearer together, but well separated from the laterals. Area of median eyes slightly wider than long. Clypeus moderately oblique, impressed transversely below eyes, slightly higher than length of median eye area. Epigynum as shown in Plate V, Fig. 4.

Male—Anterior end of pars cephalica conspicuously elevated, rounded, highest just back of anterior median eyes, bulging forward a little over clypeus which is incurved above its lower edge. A long auditory hair at distal end of tibia IV. In the palpus the tibial aphysis is much more slender than in e. g. *Cornicularis spiralis*, the genotype, and is slenderly uncate at tip. The embolus is strongly coiled in a flat spiral, which is not in part covered as it is in *spiralis*, etc. See further, Plate XVIII, Fig. 5.

Length of female, 1.7 mm. Length of cephalothorax, .77 mm. Length of tib. + pat. I, .63 mm.; tib. + pat. IV, .7 mm.

Type—M. C. Z. 444. Utah: Uintah Mts.; Chalk Creek.

This species in a group with the eastern *C. spiralis* Em. and *C. vigilax B.*, of Europe. It is strongly different from those species in the form of the tibial apophysis of the male and in the details of the eye relations, etc.

Diplocephalus wamotsus sp. nov.

Female—Carapace dusky yellow to dusky brown with the frontal gibbosity paler, often whitish, the sternum somewhat darker than carapace. Legs yellow. Abdomen grey. Posterior row of eyes more procurved than typical, but the tangent to anterior edges of its median eyes intersecting the posterior portion of the laterals; median eyes nearly their radius apart, not quite twice as far from the laterals. Anterior row of eyes slightly procurved; the medians much smaller than the laterals, sub-contiguous with each other, but widely separated from the laterals. Clypeus about as wide as length of median ocular area. Area of median eyes much longer than wide. Upper margin of furrow of chelicera armed with three well separated, long teeth; the margin with a close-set series of several very small teeth. Epigynum as shown in Plate XVIII, Fig. 7.

Male—Post-ocular gibbosity broad, with each antero-lateral corner extended as a rounded protuberance, its median region and a narrower inter-ocular region in front of it rather densely pilose; posterior median eyes borne at base of its anterior face. Posterior row of eyes very strongly procurved; the medians separated by nearly their diameter,

three times as far from the laterals. The clypeus obviously more protuberant than in female, as usual. Tibia of palpus with anterior end extended into a thin, cup-like plate embracing the base of the tarsus like a calyx and bearing a slender chitinous process from below its distal end. See Plate XVIII, Fig. 6.

Length of male, 2.8 mm. Length of cephalothorax, 1.2 mm.; width, .9 mm. Length of tib. + pat. I, 1 mm.; of tib. + pat. IV, 1.36 mm.

Type—M. C. Z. 446. Utah: Chalk Creek.

Wubana gen. nov.

Posterior row of eyes a little procurved; the median eyes farther from each other than from the laterals. Anterior row of eyes slightly procurved; eyes close together, the medians from a decidedly smaller to nearly as large as the laterals; eyes equidistant or with the medians nearer to each other than to the laterals. Area of median eyes trapeziform, much wider behind than in front, from a little longer than wide to wider than long (some males). Clypeus as high as eye area. Thoracic stria obscure. Pars cephalica in male rising behind the eye area; piligerous in a median longitudinal stripe, with a brush of longer setæ just behind the eyes which may or may not be elevated on a distinct process, one hair of this brush typically stouter, more spiniform than the others. Sternum broad, extending between posterior coxæ. Male palpus with patella not enlarged; tibia prolonged in an elongate lobe of ordinary texture along basal part of ectal side of the tarsus. Legs long and slender, anterior tarsi shorter than metatarsi, and metatarsi shorter than tibiæ.

Genotype—*W. drassoides* (Emerton).

In addition to the genotype, originally described under *Bolyphantes* and also later referred to *Sphecozone*, the new form described below and apparently also *Bolyphantes pacificus* Banks, later referred to *Nematogmus*, belong in this genus. The genus differs from *Nematogmus* in having the posterior median eyes farther from each other than from the laterals with the row at most but gently procurved, in its longer legs, in lacking postocular impressions in the male, in the form of the tibia of the male palpus and in not having the tarsus of the latter deeply bifid at the apex. From *Sphecozone* the genus differs, e. g., in having the median eyes of the posterior row farther from each other than from the laterals, in not having them borne upon the frontal lobe sometimes present in the male, in lacking the notably long pedicle to the abdomen, and in the form of the male palpus. I have taken the genotype, *W. drassoides*, originally described from Mt. Carmel, in Connecticut and until now not since recorded from elsewhere, also in the Uintah Mts., of Utah, at an elevation of 7,500 ft.

Wubana retrahens sp. nov.

Male—Cephalothorax and legs dull fulvous. Eyes edged with black. Abdomen greyish; marked above as in *W. drassoides* with a median longitudinal black line at base followed behind by several transverse dark lines; sides and part of venter dusky. Eyes of anterior row equidistant, the medians a little smaller than the laterals. Posterior row of eyes gently procurved; medians scarcely their diameter apart, nearer to the laterals. Area of median eyes longer than wide. Piligerous stripe extending from caudal end of pars cephalica forward between eyes, with no special process of elevation behind eyes beneath the brush of longer hairs. Palpus as shown in Plate XVIII, Fig. 10.

Length near 2 mm.

Type—M. C. Z. 447. Utah: Fillmore.

The male is at once distinguishable from those of *W. drassoides* and *W. pacifica* in lacking the postocular piligerous eminence. It is notably different from *W. drassoides* in having the posterior median eyes much closer together, with the area of median eyes longer than wide instead of wider than long. The structure of the male palpal organ is also a feature readily distinguishing the species.

Hilaira uta sp. nov.

Female—Carapace, sternum and endites dusky over a light brown ground, less often yellowish, the labium and cheliceræ darker. Legs dusky light brown to yellow. Abdomen grey, more or less dusky, with no markings. Posterior row of eyes straight; median eyes their diameter apart, once and a half as far from the laterals. Anterior row of eyes substraight, being very slightly recurved; medians smaller than the laterals, less than their radius apart, their diameter from the laterals. Area of median eyes subequal in length and breadth or slightly longer (11:10), narrower in front than behind in about ratio 9:10. Clypeus in height equal to length of median eye area. Epigynum as shown in Plate XVIII, Fig. 9.

Male—The palpal organ is distinctive. The spinulose submedian lobe, or apophysis, of the bulb is a notable feature. See Plate XVIII, Fig. 8.

Length of female, 3.8 mm. Length of cephalothorax, 1.8 mm.; width, 1.3 mm. Length of tibia + patella I, 1.4 mm.; of tibia + patella IV, 1.7 mm. Length of male, 2.8 mm.; of cephalothorax, 1.4 mm.

Type—M. C. Z. 448. Utah: Millard Co.; Clear Lake.

This species is readily recognizable by the form of the epigynum in the female and of the palpal organ in the male.

ARGIOPIDÆ.

Aranea (Neoscona) utahana sp. nov.

Female—This species belongs with *vertebrata* McCook in the group with longitudinal thoracic groove and having the anterior femora armed beneath with a double series of numerous stout spines. It differs from other forms of this group conspicuously in the form of the abdomen, which is rather broadly triangular-oval instead of elongate oval. The carapace grey of slightly yellowish cast marked with a conspicuous median longitudinal black band with lower border of pars cephalica also black followed on pars thoracica by one or more obscure dark spots. Sternum yellowish grey in the middle borders black. Abdomen grey with a folium on the posterior half limited on each side by a wavy black line edged with a pale line; just within the limiting line of folium on each side is a straight dusky line, while on the median region are two longitudinal dark lines close together; on each side of folium are numerous dark lines running from its edge ventrad; each anterolateral corner dark, the dark area crossed by fine vertical pale lines; midventral region black, the stripe embracing at each border two white spots, of which the anterior is the larger. Legs light yellow, deeply banded with black. The femur of anterior legs with a black submedian annulus and a broader distal one; the patella black, obscurely divided by a pale median area; the tibia with a black annulus at each end and one at the middle; and the metatarsus similarly triannulate. The tibiæ of legs III and IV lack the median black annulus as does metatarsus III, while it is present on metatarsus IV. Hairs of body in general whitish. The scape of the epigynum is in general similar to that of *vertebrata*, but is evenly curved, not at all geniculate. See Plate XIX, Figs. 1 and 2.

Length, 12 mm. Length of abdomen, 8.5 mm.; width across base, 8.2 mm. Length of cephalothorax, 5.2 mm. Length of tib. + pat. I, 7 mm.; of tib. + pat. IV, 6 mm.

Type—M. C. Z. 458. Utah: Fillmore. Webs found in sagebrush on desert flats west of the town. The color of the spiders blends with the olive grey of the sage-brush.

Aranea tusigia sp. nov.

Male—Carapace light brown above, the lower part of sides blackish brown with upper border of stripe serrate, a narrow marginal light stripe below dark area on each side. Sternum black. Legs yellow, marked with dark annuli; on femora a narrow annulus at base, a second broader one distad of middle and a third one toward distal end, the extreme distal end being of a reddish yellow cast. Tibiæ black at proximal end, at least above, and in a much broader annulus at distal end; metatarsi also dark at both ends, more narrowly so at the proximal one; tarsi darkened distally. Abdomen with folium above limited by a sinuous

light line on each side, the folium back of middle solid black and at its anterior end embracing a short median longitudinal stripe, which widens caudad; venter with a broad black stripe behind epigynum in each lateral edge of which is a yellowish spot; sides marked by fine longitudinal black lines or streaks. Thoracic furrow long, longitudinal, with no transverse impressions. The first coxa has a stout hook at distal end, while the second coxa is armed at base with a longer, stout, conical and nearly straight process. The tibia of leg II is enlarged with its mesal (anterior) surface convex; it is armed beneath with a double series of long stout spines, the posterior series in the type consisting of six spines and the anterior of three; the mesal or anterior surface in addition is armed with numerous spines in two or partially in three series, most of these spines being distad of the middle and these being much shorter and stouter than the others, about seventeen spines in all on the anterior surface. Palpus of male of characteristic form. See Plate XIX, Fig. 3.

Length, 8 mm. Length of cephalothorax, 4.2 mm. Length of tib. + pat. I, 5 mm.; of tib. + pat. IV, 4.2 mm.

Type—M. C. Z. 461. Utah: Chalk Creek.

CLUBIONIDÆ.

Clubiona orinoma sp. nov.

Female—Carapace dull yellow of slightly brownish cast. Sternum and legs light yellow. Labium and endites brown. Cheliceræ light chestnut. Abdomen beneath light yellowish grey; dorsum reddist brown over a yellow ground with a narrow median longitudinal reddish line from base to behind middle, this pointed at caudal end; sometimes fine pale chevron lines traceable on posterior region. Lower margin of furrow of chelicera armed with two moderately stout teeth with sometimes distad of these a number of granular elevations. Anterior row of eyes straight; eyes less than their radius from lower margin of clypeus, equidistant, nearly their diameter apart. Posterior row of eyes much longer than the anterior with eyes smaller; row straight; median eyes two and a half times their diameter apart, twice their diameter from the laterals. Area of median eyes much wider than long, wider behind than in front in about the ratio 22:15. Tibia I and II armed beneath with two pairs of spines, the corresponding metatarsi each with a single basal pair. Epigynum as shown in Plate XIX, Fig. 4.

Length, 6.5 mm. Length of cephalothorax, 2.6 mm. Length of tib. + pat. I, 2.2 mm.; of tib. + pat. IV, 2.2 mm.

Type—M. C. Z. 474. Utah: Chalk Creek.

AGELENIDÆ.

Agelena mimoides sp. nov.

Male—Carapace with the usual broad median longitudinal dorsal yellow stripe and yellow lateral stripes; a marginal dark line on each side; the lateral dark bands rather narrow, with lower edge uneven; eyes edged with black. Legs yellow, in type, with some vague darker markings on femora, but with not distinct annuli. Sternum yellow, a little deeper at the edges. Labium and endites darker, pale at tips. Cheliceræ light chestnut. Abdomen beneath immaculate light greyish yellow in middle region, an interrupted longitudinal dark line or series of dark spots toward each side; dorsally a broad longitudinal yellow stripe bordered with dark, the mesal edge of which is uneven or serrate and enclosing a vague saggittate outline in basal half. Lower margin of furrow of chelicera armed with two teeth as in *californica* and *pacifica*. Anterior median eyes smaller than the laterals, less than their radius apart and from the laterals. Posterior median eyes three-fourths or scarcely more their diameter apart, their diameter from the laterals. Tibia I armed beneath with three pairs of spines; tibia II with a single spine at base and a submedian and apical pair. The palpus of the male parallels in general structure that of *A. pacifica.* The most readily noted differences are in the tibia and its processes. In the dorsal view the excavation is seen to be more extensive, extending slightly farther mesad; the limiting posterior ridge presents a distinct process above which is always lacking in *pacifica* and in lateral view is seen to continue evenly out along the lateral apophysis, instead of showing an abrupt interruption. Other differences are noticeable in the details of the palpal organ. See Plate XIX, Figs. 5 and 6.

Female—The epigynum of the female is distinguished in having the posterior region more widely elevated with the lateral spurs weaker and more widely separated.

Type—M. C. Z. 464. Utah: Fillmore Canyon.

Cicurina garrina sp. nov.

Female—Carapace, sternum, and legs pale brown, the legs darker distally, the posterior pair somewhat chestnut. Labium, endites and cheliceræ chestnut. Abdomen immaculate grey. Eyes of anterior row equidistant, the medians about five-sevenths the diameter of the laterals. Posterior median eyes equal size to the anterior medians, the posterior laterals scarcely smaller than the anterior laterals. Posterior median eyes once and a half their diameter apart, their diameter from the lateral on each side. Cheliceræ strongly geniculate; lower margin typically with three stout teeth followed by three much smaller ones. Tibia I armed beneath with three pairs of spines, the anterior side with three single spines of which the most proximal one is subventral. Metatarsus I with three pairs of spines, the anterior face with two spines. Tibia II armed beneath with 1-1-2 spines. Epigynum, Plate XIX, Fig. 9.

Male—The palpus very similar to that of *C. arcuata*, but differing in details.

Length of female, 9 mm. Length of cephalothorax, 3.2 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.1 mm.

Type—M. C. Z. 470. Utah: Chalk Creek, elevation 8,000 ft.

A species much resembling the Louisianan *C. ludvoiciana* Simon in coloration, proportions and general structure. It may be distinguished in having the posterior median eyes much farther apart than from the laterals, instead of these eyes being equidistant, in having three spines on the anterior face of tibia I instead of but two; metarsus I with two spines on anterior side, instead of but one, etc.

Cicurina utahana sp. nov.

Female—A small form with carapace and sternum yellow, the legs more brownish especially distad. Carapace glabrous or nearly so. Abdomen grey, immaculate, the epigynum light chestnut. Lower margin of furrow of chelicera armed with four teeth, a minute fifth one detectable on one side in the type. Posterior row of eyes straight: median eyes smaller than the laterals, nearly their diameter from the latter, slightly farther from each other; posterior medians obviously smaller than in arcuata and the spacing of the posterior eyes more nearly equidistant. Epigynum, Plate XIX, Fig. 8.

Length, 5.2 mm. Length of cephalothorax, 2+mm. Length of tib. + pat. I, 1.8 mm.

Type—M. C. Z. 467. Utah: Millard Co.; Pine Canyon.

Cicurina utahana anderis subsp. nov.

Female—This form very much resembles in size and coloration the typical *C. utahana*. The epigynum is also very similar, but is proportionately smaller with the intermediate loop of the seminal duct on each side rising only a little farther forward than the ectal loop. The types differ from *utahana* in the spining of the anterior legs. Tibia I is armed beneath with three pairs of spines instead of two pairs, with two spines on the anterior face. Tibia II bears beneath three spines in line toward the caudal side with a fourth one paired with the most distal of these at distal end while on the anterior face is but a single spine; in utahana, on the other hand, there are but two spines beneath toward the caudal side with one distal spine not in line with these, while there are two spines on the anterior face.

Length, 6 mm. Length of cephalothorax, 2.1 mm. Length of tib. + pat. I, 1.8 mm.; of tib. + pat. IV, 2 mm.

Type—M. C. Z. 469. New Mexico: San Geronimo.

Cicurina idahoana sp. nov.

Female—Carapace and legs yellowish brown. Abdomen cinerous, without markings. Posterior row of eyes straight; eyes large, the medians smaller than the laterals; median eyes separated from the laterals by about their diameter, farther from each other. Anterior row of eyes procurved; medians smaller than the laterals, their radius or less apart, nearer to the laterals. Area of median eyes wider behind than in front, wider than long. Tibia I armed beneath with three pairs of spines and on the anterior face with three single spines of which two more proximal ones are much nearer to each other as usual. Metatarsus I armed beneath with three pairs of spines and with one spine on anterior face proximad of middle. Tibia II and Metatarsus II also armed beneath each with three pairs of spines. The species is readily recognizable by the structure of the epigynum (Plate XIX, Fig. 10).

Length, 7 mm. Length of cephalothorax, 3.1 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.2 mm.

Type—M. C. Z. 466. Idaho: Moscow Mts., J. A. Hyslop, coll., 1910.

LYCOSIDÆ.

Pardosa utahensis sp. nov.

Female—A small form apparently closely related to *P. emertoni* Chamb. It is a much darker species, though with the dorsal markings corresponding. Carapace with integument brown, with a straight black stripe along each side, a black marginal line and above it a heavier black supramarginal line; eye region black; the light stripes clothed densely with bright white hair, which is a little rufous about eyes. Sternum black, excepting a pale median region, instead of pale yellow with simply small marginal black dots. Legs dusky brown. Abdomen with dorsum black along each side, leaving a pale, caudally narrowing stripe over entire length, this enclosing anteriorly a dark hastate mark; venter dark grey; epigynum dark chestnut; light areas clothed in life with bright white hair. Anterior row of eyes much shorter than the second, about equalling the distance from center to center of the eyes of the latter; a little procurved; median eyes obviously more widely separated than in emertoni, clearly more than their diameter apart and less than their diameter from the laterals. Eyes of second row once and a half their diameter apart. Anterior tibiæ and metatarsi armed beneath as usual, the first two pairs of spines being very long and slender with the first widely overlapping the second. Epigynum as shown in Plate XIX, Fig. 11.

Length, 6.5 mm. Length of cephalothorax, 2.9 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.6 mm.

Type—M. C. Z. 385. Utah: Chalk Creek, elevation 8,000 ft., August, 1917.

EXPLANATION OF PLATES.

Plate XIV.

Fig. 1. Epigynum of *Amaurobius nomeus* sp. nov.
Fig. 2. Male palpus, dorsal view, of the same.
Fig. 3. Right chelicera, ectal view, of *Dictyna uintana* sp. nov.
Fig. 4. Epigynum of the same.
Fig. 5. Right male palpus, ectal view, of the same.
Fig. 6. Left chelicera, of male, ectal view, of *Dictyna coloradensis* sp. nov.
Fig. 7. Epigynum of the same.
Fig. 8. Right male palpus, ectal view, of the same.

Plate XV.

Fig. 1. Epigynum of *Dictyna vincens* sp. nov.
Fig. 2. Right male palpus, ectal view, of the same.
Fig. 3. Right chelicera, ectal view, of *Dictyna bellans* sp. nov.
Fig. 4. Epigynum of the same.
Fig. 5. Right male palpus, ectal view, of the same.
Fig. 6. Right male palpus, ectal view, of *Dictyna insolens* sp. nov.
Fig. 7. Right male palpus, ectal view, of *Dictyna olympiana* sp. nov.
Fig. 8. Epigynum of *Dictyna sociella* sp. nov.

Plate XVI.

Fig. 1. Epigynum of *Dictynoides arizonensis* sp. nov.
Fig. 2. Epigynum of *Drassodes robinsoni* sp. nov.
Fig. 3. Left male palpus, ectal view, of *Drassodes gosiutus* sp. nov. (All hairs and spines omitted as usual, excepting ventral distal spines of tarsus.)
Fig. 4. Left male palpus, ectal view, of *Drassodes melius* sp. nov.
Fig. 5. Epigynum of the same.
Fig. 6. Left male palpus, ectal view, of Heryullus oabus sp. nov.
Fig. 7. Epigynum of Zelotes tuobus sp. nov.

Plate XVII.

Fig. 1. Right male chelicera, ectal view, of *Psilochorus utahensis* sp. nov.
Fig. 2. Right male palpus, ectal view, of the same.
Fig. 3. Left male palpus, ectal view, of *Linyphia latescens* sp. nov.
Fig. 4. Epigynum of *Linyphia orinoma* sp. nov.
Fig. 5. Epigynum of *Bathyphantes fillmorana* sp. nov.
Fig. 6. Epigynum of *Grammonota obesior* sp. nov.
Fig. 7. Epigynum of *Grammonota orites* sp. nov.
Fig. 8. Right male palpus, ectal view, of the same.
Fig. 9. Right male palpus, dorsal view, of the same.

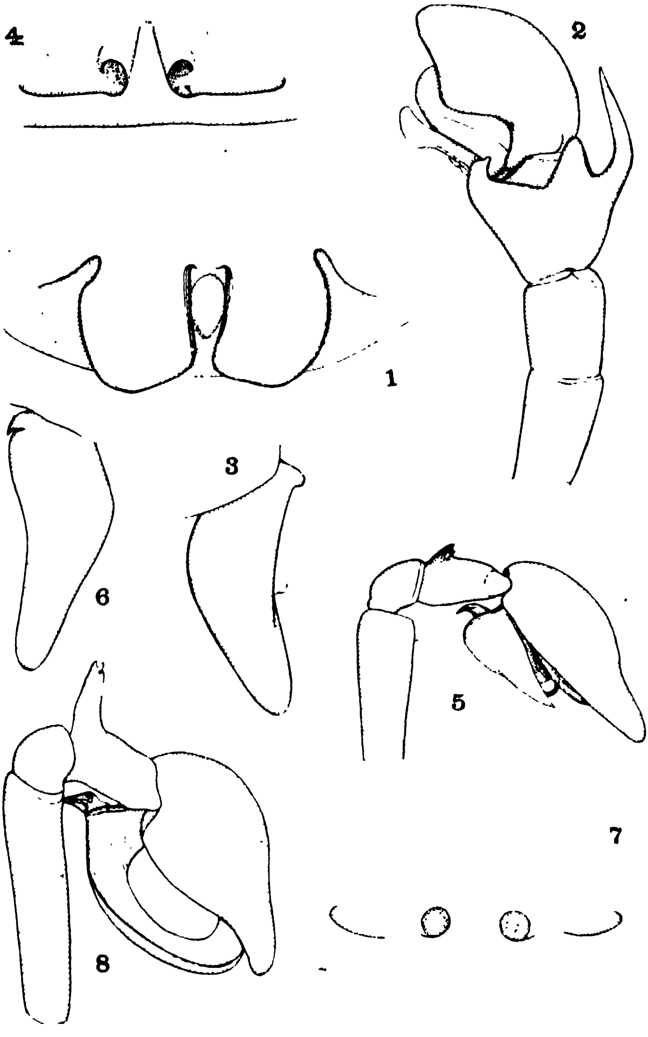
Plate XVIII.

Fig. 1. Left male palpus, ectal view, of *Grammonota simplex* sp. nov.
Fig. 2. Epigynum of the same.
Fig. 3. Epigynum of *Grammonota fratrella* sp. nov.
Fig. 4. Epigynum of *Cornicularia monticolens* sp. nov.

Fig. 5. Left male palpus, ectal view, of the same.
Fig. 6. Left male palpus, ectal view, of ***Diplocephalus wamotsus*** sp. nov.
Fig. 7. Epigynum of the same.
Fig. 8. Left male palpus, ectal view, of ***Hilaira uta*** sp. nov.
Fig. 9. Epigynum of the same.
Fig. 10. Right male palpus, dorsal view, of ***Wubana retrahens*** sp. nov.

PLATE XIX.

Fig. 1. Epigynum, ventral view, of ***Aranea utahana*** sp. nov.
Fig. 2. Epigynum, lateral view, of the same.
Fig. 3. Left male palpus, ectal view, of ***Aranea tusigia*** sp. nov.
Fig. 4. Epigynum of ***Clubiona orinoma*** sp. nov.
Fig. 5. Right male palpus, ectal view, of ***Agelena mimoides*** sp. nov.
Fig. 6. Tarsus of right male palpus, dorsal view, of the same.
Fig. 7. Epigynum of ***Agelena naevia*** Hentz, variety (Uintah Mts.)
Fig. 8. Epigynum of ***Cicurina utahana*** sp. nov.
Fig. 9. Epigynum of ***Cicurina garrina*** sp. nov.
Fig. 10. Epigynum of ***Cicurina idahoana*** sp. nov.
Fig. 11. Epigynum of ***Pardosa utahensis*** sp. nov.



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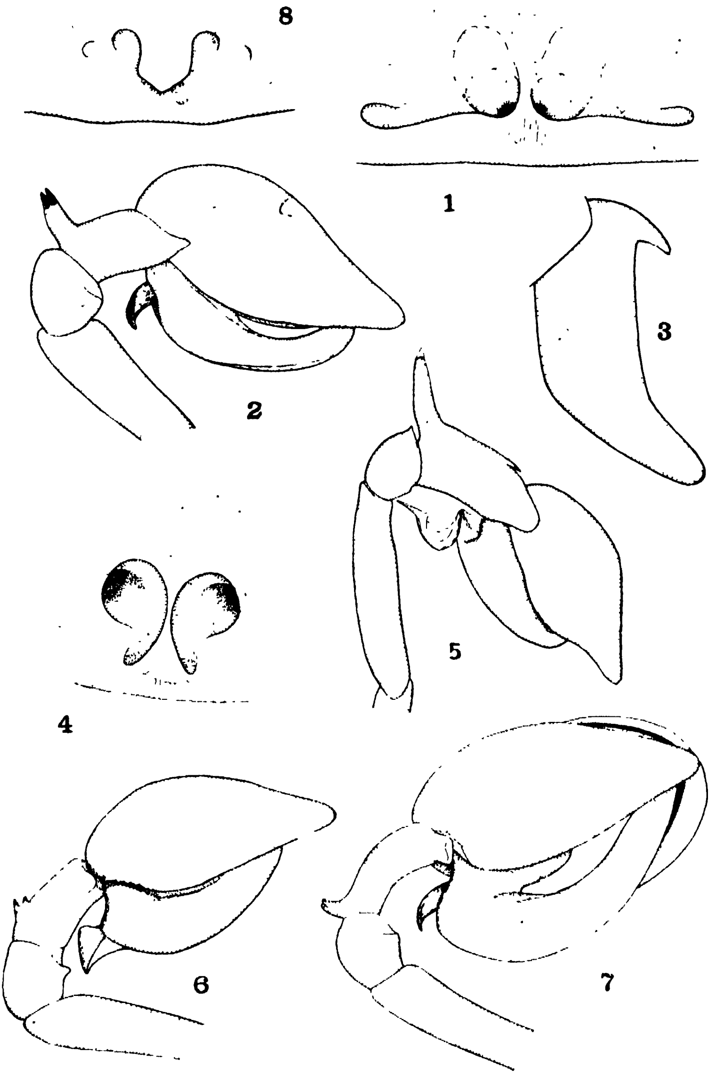

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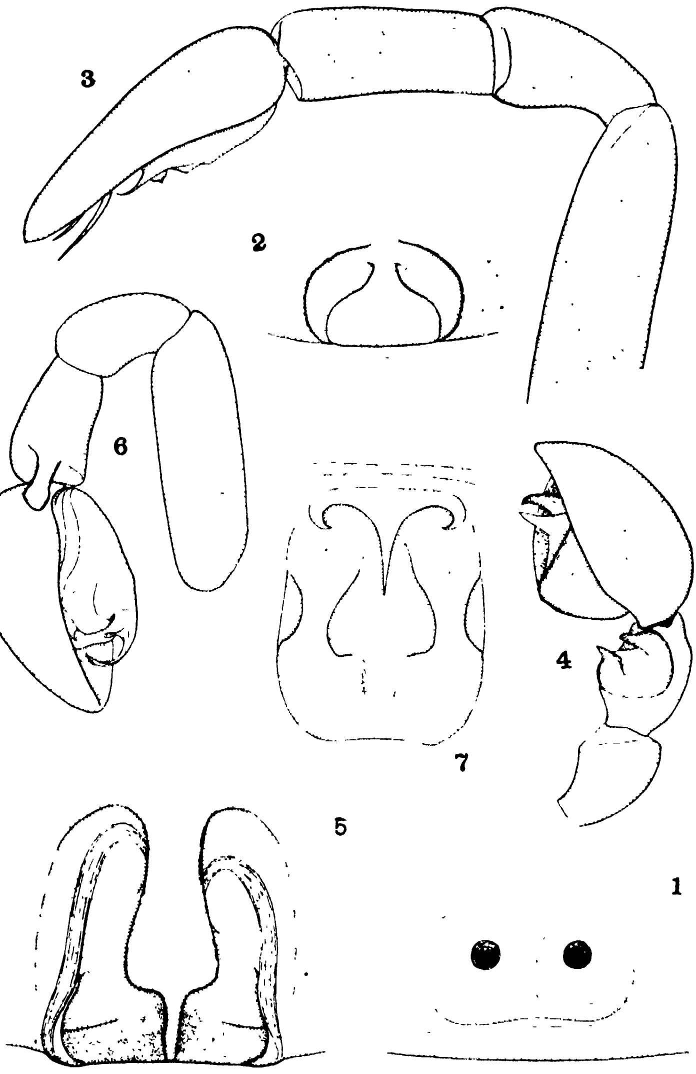

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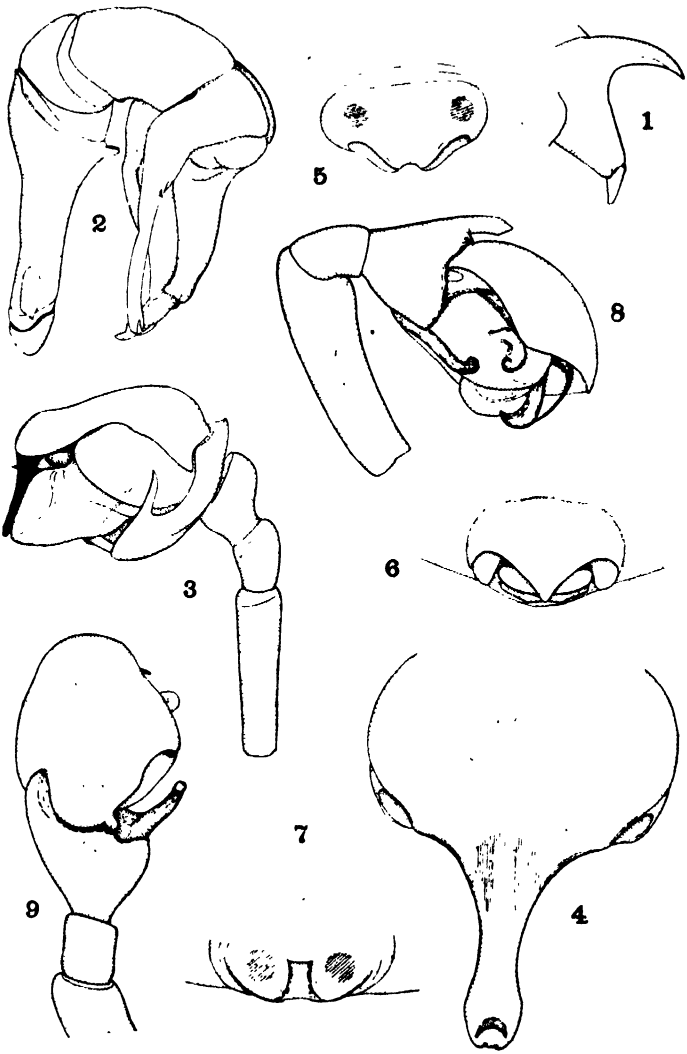

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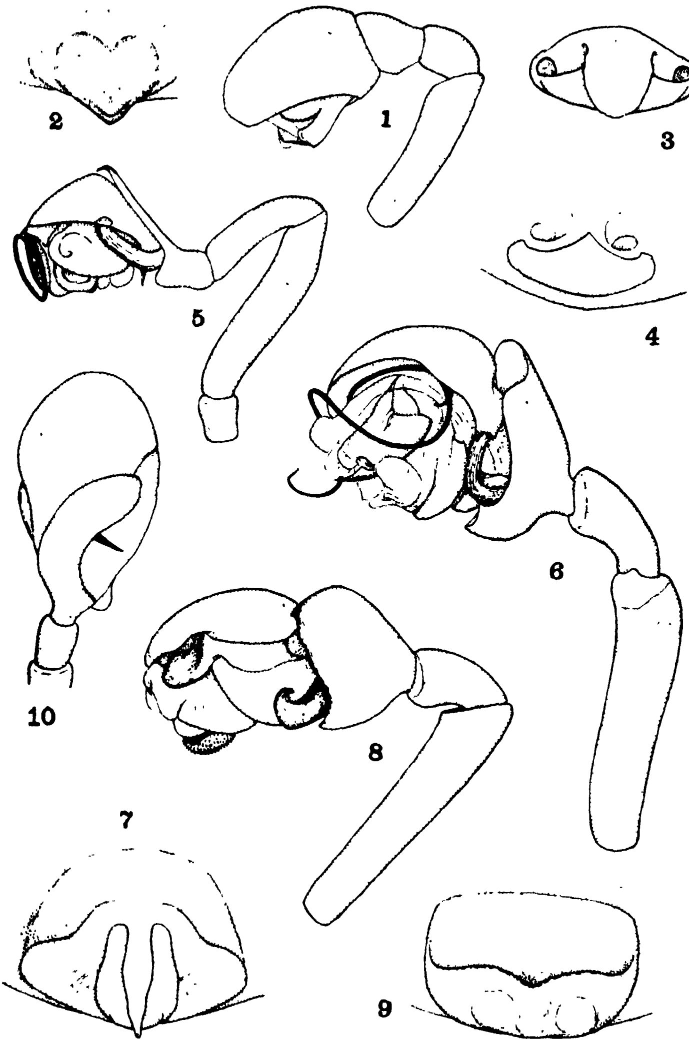

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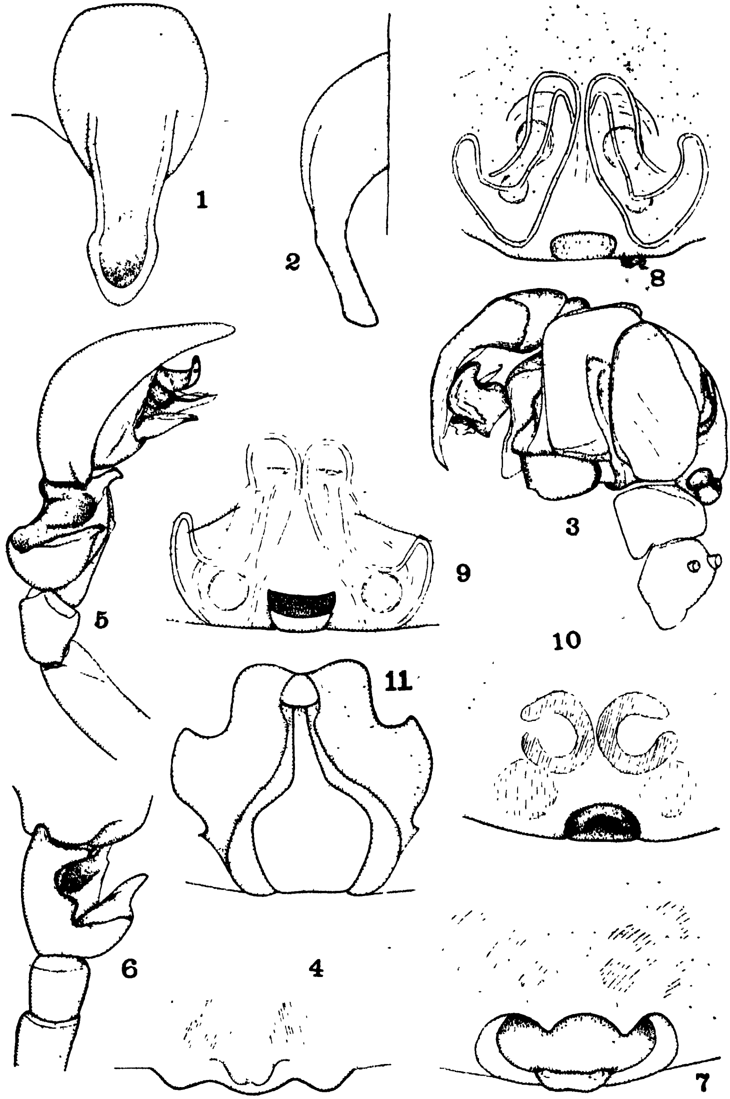

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THE TERMINAL ABDOMINAL STRUCTURES OF ORTHOPTEROID INSECTS: A PHYLOGENETIC STUDY.

By E. M. Walker, Toronto, Ont.

INTRODUCTION.

There is still much difference of opinion concerning the inter-relations of the various orders of insects, particularly of the so-called "lower" orders, and even the question as to what are the limits of these orders is by no means a matter of general agreement.

If these problems are ever to be solved in a logical manner, all the available data must be taken into account. The evidence afforded by comparative anatomy, ontogeny and palaeontology, or any facts bearing upon the subject, must all be fairly considered. Although much information has been accumulated from these various sources, there are still important fields which have received much less attention than they deserve. In the field of external morphology the greatest advances have been made in the study of wing-venation, which, thanks to the classical labors of Comstock and Needham, now rests upon a thoroughly sound basis; the mouth-parts have also long been a favorite subject for investigation, while in comparatively recent years, good progress has been made in the study of the thoracic and cervical sclerites, particularly by Snodgrass and Crampton.

Our knowledge of the terminal abdominal structures, especially the genitalia and associated parts, is still, however, in a very unsatisfactory state. A constantly increasing value is being attached to them by systematists in separating genera

and species, but the specialist is seldom interested in these structures except in so far as they afford good taxonomic characters in the groups with which he is concerned, and does not trouble himself to inquire into their homologies with the corresponding parts in other orders. The natural result of this is a multiplicity of terms and a great lack of unanimity in their application.

The most fundamental upheaval of our generally accepted ideas of insect classification that has occurred in comparatively recent years is the system advocated by the eminent student of fossil insects, Anton Handlirsch. This system, which was first proposed in 1903,[1] and elaborated in 1908 in his monumental work, "Die fossilen Insekten," is well known, and its deviations from previously accepted views are due mainly to the study of the fossil record. His division of the old class Insecta (Hexapoda) into five classes—Collembola, Campodeoidea, Protura, Thysanura and Pterygogenea—is not based directly upon palaeontological evidence, but on general considerations of structure; but the splitting up of the old order Orthoptera is founded upon the actual fossil record, so that the question as to whether or not the findings of comparative morphology support his views becomes one of considerable importance.

The present study of the genitalia and associated parts of the groups commonly called Orthoptera is offered as a contribution to this subject and, at the same time, an effort has been made to clear up certain general questions on the homologies of the parts concerned.

Before proceeding with the discussion of the terminal abdominal structures, it may be useful to give a brief summary of Handlirsch's views in so far as they relate to the origin and relationships of the various groups still commonly known as Orthoptera, i. e., the Blattidæ, Mantidæ, Phasmidæ, Acrididæ and Acrydiidæ (Tettigidæ)*, together with such other groups as may appear to be more or less closely related to them.

The earliest undoubted insect remains belong to the Carboniferous era. They are all winged insects of comparatively large size, some of them very large. Eleven orders are recog-

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[1] Handlirsch, 1903. Zur Phylogenie der Hexapoden. Vorläufige Mitteilung. Sitzb. K. Akad. Wiss., Bd. 112, Heft 8, Abt. 1, pp. 716–738, Taf. 1.

* The Acrydiidæ of Most Authors.

nized by Handlirsch as belonging to this period, only one of which, the Blattoidea, is represented among the orders of the present age, although four others, viz., the Protorthoptera, Protoblattoidea, Protodonata and Protephemeroidea, appear to be the direct forbears of the Orthoptera, Mantoidea, Odonata and Plectoptera (Ephemerida) respectively.

A large proportion of the insects of this period are characterized by their extremely generalized structure and are regarded by Handlirsch as the groups from which all other winged insects, or Pterygogenea, have descended. These are the Palaeodictyoptera. Their two pairs of ample wings were similar in size, form and venation, the latter being remarkably like the hypothetical type on which the Comstock-Needham system is founded.

The Protoblattoidea and Protorthoptera are independently connected with the Palaeodictyoptera by forms which differ very slightly from the latter, while, on the other hand, the most primitive Blattoidea, such as *Polyctoblatta*, grade almost insensibly into the Protoblattoidea. The latter group consisted of more elongate forms than the true Blattids, having a less regularly elliptical outline, and usually a longer prothorax and a more exposed and prognathous head. Some of them, at least, had a well-developed exserted ovipositor.

The Protoblattoidea died out in the Permian, where the first true Mantids appeared, these differing in venation very little from the former group.

The Blattoidea are considered to be the forbears, not only of their modern representatives, but also of the Isoptera, Corrodentia (Psocidæ), Mallophaga and Siphunculata (Anoplura). None of these groups are known before the Tertiary epoch, and the fossil record offers no clues as to their relationships. Handlirsch is probably correct with respect to the Isoptera, although they may well have arisen at a much earlier age than the Cretaceous.

The Protorthoptera, which also persisted into the Permian, embraced a considerable number of families and genera. They were elongate forms, some with ambulatory legs and prognathous phasmid-like heads, while others had saltatorial hind legs like those of modern Orthoptera. An elongated ovipositor was present in some, if not all, forms(e. g., *Dieconeura arcuata* Scudd.) None possessed stridulatory organs.

No Orthopteroid insects are known from the Trias, the insect record of which is very scanty, but true Orthoptera appear in the Lias, belonging to several groups, some of which were silent while others possessed stridulating organs.

Among the former were the Locustopsidæ, which had antennæ and an ovipositor of the Tettigoniid type, but wing venation more like that of the Acridoidea, and, like the latter, lacked the stridulatory apparatus in the male tegmina. True Acridoidea are known from the lower Tertiary, so they were probably derived from the Locustopsidæ during Cretaceous times. The stridulating forms were in part, at least, true Gryllidæ, and Handlirsch concludes that from primitive non-stridulating saltatorial stock two branches arose, one leading to the common ancestors of the Gryllidæ and Locustidæ (Tettigoniidæ), the other giving rise to the Elcanidæ and Locustopsidæ, from which latter the Acridioidea were evolved. He regards the Tridactylidæ as probably derivatives of the Elcanidæ, some of which, like *Tridactylus*, possessed peculiar lobe-like swimming appendages on their hind tibiæ.

Other orders which Handlirsch assigns to the Orthopteran stem are the Dermaptera, "Diploglossata" and Thysanoptera. These groups are unknown below the Tertiary epoch, and this fact has evidently influenced Handlirsch's judgment in his attempt to find suitable ancestors for them in the Orthoptera of the Cretaceous.

The Ephemerida, Odonata and Plecoptera are considered to have no direct relationship with each other or with other orders except through their Palaeodictyopterous ancestors.

Since the publication of "Die fossilen Insekten," two new orders of insects have been discovered which must be considered in any discussion of the phylogeny of the orthopteroid groups. These are the Zoraptera, represented by a single genus, *Zorotypus* Silvestri ('13)[2] containing five species, and the Grylloblattoidea, likewise represented by one genus, *Grylloblatta* Walker ('14)[3] with a single species (*G. campodeiformis*). The former group is compared by its author with the Isoptera and Blattidæ and also with the Dermaptera (*teste* Caudell) and

[2] Silvestri, Fil., Ballet. Lab. Zool. Gen. Agric. Portici, Vol. VII, pp. 193–209, Figs. i-xiii (1913).

[3] Walker, E. M., Can. Ent., Vol. XLVI, pp. 93–99, Pl. VI (1914).

Crampton ('15)[4] considers them as probably members of the "Panisoptera," to which the first two named groups belong. Caudell[5] likewise finds their nearest allies in the Isoptera. Unfortunately, I have been unable to obtain specimens of *Zorotypus* and can therefore add nothing to what has already been written concerning it.

The systematic position of *Grylloblatta* has been discussed in several papers by Crampton[6], as well as in the original description by the present writer (loc. cit.). Its extraordinary synthetic character is indicated by the variety of orders with which it has been found to have important features in common.

As regards Prof. Crampton's opinions on the relationships of the Orthopteroid orders in general, a few words may be said here. He has expressed views on this subject in several papers ('15, '16, '17, '18, '19)[7] and these have been modified somewhat from time to time, especially with regard to the position of Grylloblatta, which will be discussed later. His latest views appeared in a paper entitled "Notes on the Phylogeny of the Orthoptera," and are summarized in his diagram on p. 43 ('19).[7] They differ from those of Handlirsch mainly in the following points:

1. The Isoptera, owing to the possession of certain primitive characters not found in living Blattids and Mantids, are represented as arising, not directly from the Blattid branch, but from the base of the common stem of the Blattidæ and Mantidæ, or possibly somewhat farther along its path of development.

2. The Phasmidæ arose, not from Saltatorial Orthoptera (Locustopsidæ), but from near the base of the common Orthopteran stem, a view which is supported particularly by the presence of Plecopteroid characters in the primitive Phasmid, *Timema californica*.

3. The Dermaptera are likewise not regarded as of Orthopteran origin, but are separately derived from the common stock, from which all the pterygote orders arose.

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[4] Crampton, G. C. Ent. News, Vol. XXVI, p. 343 (1915).

[5] Caudell, A. N. Can. Ent., Vol. L, p. 381 (1918).

[6] Crampton, G. C., Ent. News, Vol. XXX, pp. 42–48, 64–65 (1919). (See also following footnote.)

[7] Crampton, G. C., Ent. News, Vol. XXVI, pp. 337–350, Pl. XIII (1915); Ent. News, Vol. XXVII, pp. 244–258, 297–307 (1916); Can. Ent., Vol. XLIX, pp. 213–217, Fig. 9 (1917); Ent. News, Vol. XXVIII, pp. 398–413, Pl. XXVII (1917); Journ. N. Y. Ent. Soc., Vol. XXV, pp. 225–237 (1917); Bull. Brooklyn Ent. Soc., Vol. XIII, pp. 49–68, Pls. II–VII (1918); Ent. News, Vol. XXX, pp. 42–48; 64–72 (1919).

4. The Dermaptera, Embiidina and Plecoptera are grouped together more closely than is done by Handlirsch, who recognized no near affinities among them.

In other respects Crampton's diagram is not incompatible with Handlirsch's views, so far as it goes, but in regard to the relationship of other orders not included among the "Orthopteroid" groups, but believed by Handlirsch to be derived from Orthopteroid ancestors (including Blattoid and Protoblattoid derivatives) his views are very different. These, however, do not concern us here.

In general Crampton believes that the Plecoptera rather than the Blattoidea most nearly represent among living insects the ancestral stock from which the Orthoptera and Phasmoidea have developed, while Grylloblatta has its closest affinities among the Mantids, Embiids and Dermaptera, and its line of descent is therefore represented as coming from the ancestral stock common to the Panisoptera and Panplecoptera. This view differs somewhat from former views expressed by this same author, in which he placed Grylloblatta in his super-order "Panorthoptera," with the Orthoptera and Phasmoidea. The position of this important annectant form will be further discussed at a later stage.

THE TERMINAL ABDOMINAL STRUCTURES.

Two papers by Crampton ('17 and '18)[8] have recently appeared, in which these structures in the more primitive orders are discussed from the comparative standpoint. In the earlier paper, which deals with the female, the author states that "the neck and cervical structures furnish far more definite characters for grouping these insects than the terminal abdominal structures of the female do," and in another paper already cited ('19, p. 64), he emphasizes the phylogenetic importance of the former structures on account of their being remarkably constant within an order or superorder and less subject to such variations as depend upon changes of function. While admitting the general truth of this statement, it should be kept in mind that such characters as were present in the common ancestors of all insects may be inherited by some of

[8] Crampton, G. C., Jour. N. Y. Ent. Soc., Vol. XXV, No. 4, Pls. XVI, XVII (1917); Bull. Brooklyn Ent. Soc., Vol. XIII, pp. 49–68, Pls. 2–7 (1918).

the members of any of the orders, and that they may therefore be of little phylogenetic value except in determining the primitive form of the structure concerned or in deciding which forms in a particular group are its most primitive members. Specialized characters, when the factor of convergence can be eliminated, are often of more value than primitive ones, particularly in complex structures where an opportunity for detailed comparison is present. For instance, the arrangement of the mouth-parts of the Diptera or the Lepidoptera is so distinctive that these structures alone serve as recognition marks of these orders. It is largely this feature which renders wing-venation so useful in phylogenetic studies of insects, and although I should not attribute the same value to the genitalia, I do claim that they are of great phylogenetic importance when studied in detail; and in this connection I may point out that Prof. Crampton's studies of the thoracic and cervical sclerites are very much more thorough than those of the genitalia. The chitinous parts of the genitalia are in large measure internal structures and unless their internal relations are carefully investigated one is certain to be led to false deductions.

In another recent paper by Dr. A. G. Newell ('18)[9] the view is held that the gonapophyses in both sexes represent three pairs of serial appendages or limbs, belonging to the 8th, 9th and 10th abdominal segments; and an attempt is made to identify these appendages in both sexes of all the orders. Although a useful summary of the literature dealing with the subject of insect genitalia is given, the investigation itself betrays a lack of grasp of the fundamental principles involved, and the facts of comparative morphology and development as given in the bibliography cited appear to have been almost entirely ignored.

The material on which the present study is based was obtained from various sources. For the gift or loan of specimens, indispensable to the work, I am especially indebted to the following gentlemen, to whom I take pleasure in expressing my most sincere thanks: Prof. G. C. Crampton, Dr. C. Gordon Hewitt, Dr. N. Banks, Dr. L. O. Howard, Mr. Thos. E. Snyder, Mr. Morgan Hebard and Mr. W. Downes.

[9] Newell, Anna Grace, Annals Ent. Soc. Am., Vol. XI, No. 2, pp. 109–142, Pls. IV–XVI.

PART I. THE TERMINAL ABDOMINAL STRUCTURES OF THE FEMALE.

The female external genitalia of a typical generalized Pterygote insect (e. g., *Ceuthophilus*, Figs. 1–4), consist of the *vulva* or genital aperture, situated at or near the posterior end of the eighth abdominal sternum and usually protected by a backward prolongation of the latter (in some cases the seventh sternum), the *subgenital plate* (st. 8); and three pairs of processes, the *gonapophyses* or *valvulæ*, which co-operate to form the ovipositor. These valvulæ are distinguished, from their usual positions, as the *ventral*, *dorsal* and *inner valvulæ* (valves) or the *anterior*, *lateral* and *posterior gonapophyses*, respectively. The ventral valvulæ arise primitively from the posterior margin of the eighth sternum, though often actually from the intersternal membrane between segments eight and nine; the dorsal and inner valvulæ from the ninth sternum, primitively also from the posterior margin.

The ventral valvulæ (vv) consist of a shorter basal segment, the *basivalvula* (Crampton, '17)[10] and a longer *shaft*. The basivalvula (bs) is usually chitinized only ventrally or ventro-laterally, if at all, the shaft externally, when a functional structure, but becoming partly or entirely membranous when the ovipositor is degenerate.

The dorsal valvulæ (vd) may be more or less distinctly separable into a broad proximal portion and a longer, more slender distal part, but there is no line of demarcation between these parts and nothing comparable to the basivalvulæ; the parts so designated by Crampton being in some cases the lateral part of the ninth sternum (or valvifer, *vide inf.*)[11]; in other cases merely the basal part of the valvula itself,[12] the appearance of a suture being due to parts beneath showing through the valve.

The inner valvulæ (vi) are enclosed by the other two pairs and are usually the shortest pair. They commonly enclose or roof over, the passage through which the eggs are passed out

[10] Crampton, Journ. N. Y. Ent. Soc., Vol. XXV, p. 236 (1917). Also termed "Basalstuck" (Van der Weele, Tijd. voor Ent., Deel XLIX, pp. 99–198, Pls. 1–3, 1906), and "basal plate" (Walker, Univ. of Toronto Studies, Biol. Ser., No. 11, 1912).

[11] Crampton, op. cit., Pl. XVI, Fig. 7; Pl. XVII, Fig. 12.

[12] Crampton, op. cit., Pl. XVI, Figs. 1, 6; Pl. XVII, Fig. 10.

in oviposition. Very frequently the inner valves are connected from the base distad to a varying extent by a fold of integument, which may be termed the *intervalvular membrane* (im). The inner valvulæ are generally chitinized laterally and these hardened parts or *rami* (rm) are connected by a strengthening bar or *pons valvularum* (p) across the membrane, or the entire fold may be chitinized dorsally. In the former case it is sometimes convenient to distinguish proximal and distal portions of the rami according to their position in relation to the pons. Like the ventral valvulæ, the dorsal and inner pair may be largely or wholly membranous when functionally degenerate.

Between the bases of the dorsal valvulæ and often closely connected or even fused with them, is a median sclerite, the *superior intervalvula* (sv). It bears a median vertical apodeme for the attachment of important muscles connected with the movements of the ovipositor, and its outer surface is continuous below with the upper surface of the intervalvular membrane. In some forms, such as *Mantis* and *Stagmomantis*, the rami of the inner valves may be fused with this plate. Another median sclerite, the *inferior intervalvula* (iv), is found on the ventral surface of the base of the intervalvular membrane. With the inferior intervalvula the rami of the inner valvulæ are frequently connected, as in the Tettigoniidæ and Acrididæ, and they are always connected more or less closely with a strong ventral process from the base of each dorsal valvula, which may be termed the *inferior apophysis* (iap). A similar but usually larger process, the *superior apophysis* (sap) projects forward into the hæmocœle from the upper part of the base of the valvula. Both pairs of apophyses serve for muscular attachment.

The dorsal and ventral valvulæ meet laterally at their bases, where they are both joined by a small plate, of more or less triangular form, the *valvifer* (Crampton)[13] (vf). This sclerite represents the antero-lateral part of the ninth sternum and its outer (upper) anterior angle is connected with an apodeme in the form of a ridge following the constriction between segments 8 and 9 (ap. 9, int. ap.). The ridge is generally continued along the front margin of the valvifer and also often along the lateral margin (using these terms in a morpho-

[13] The "épimerite" of Lacaze-Duthiers. Ann. Sc. Nat., 3 série, Zool., tome 17, pp. 207–251, Pls. 10, 11, 12 (1852).

logical sense), and near its lower end it is sometimes raised into a prominent internal process (pap) for the attachment of muscles. In the Acridoidea this process reaches an enormous size, although the valvifer and ridge are greatly reduced or absent.

Distal Valvular Connections.

The manner in which the valvulæ are connected beyond the base varies greatly, depending upon differences in the methods of oviposition. As a rule the dorsal and ventral valvulæ form a sheath enclosing the inner valvulæ, the dorsal frequently overlapping or roofing over both ventral and inner valvulæ. Very frequently the inner and ventral valvulæ fit together more or less firmly by a tongue-and-groove joint extending along their adjacent outer edges for the greater part of their length, and in some cases (most Tettigoniidæ) such a joint also occurs between the dorsal and ventral valvulæ. In both cases the ventral valvulæ bear the groove or grooves, the other valvulæ the tongues. Where such connections exist the only possible movements of the valvulæ in relation to one another are sliding movements backwards and forwards. These are best seen in the Tettigoniidæ and doubtless also occur in *Grylloblatta*. In the Gryllidæ, in which the inner valvulæ are vestigial, the dorsal and ventral pair are immovably united with one another at the apices and no movement takes place between them. In the Acrididæ, Acrydiidæ and Tridactylidæ (*Ripipteryx*), on the other hand, the dorsal and ventral valvulæ are free beyond their bases, and can be moved in the sagittal plane like a pair of forceps, of which the dorsal pair form one of the jaws, the ventral pair the other. In the Phasmoidea, Mantoidea and Blattoidea, the valvulæ are more or less flexible and apparently not functional in the forms studied. There is no close connection between them beyond the base, although there is usually an ineffective tongue-and-groove engagement between the inner and ventral valvulæ.

Development of the Ovipositor.

The first indication of the ovipositor (Fig. 9) is generally a pair of tubercles on the ninth sternum, sometimes on the hind margin, but more frequently farther forward. These are soon followed by two other pairs, one from the hind margin of the eighth sternum, or just behind it, the other from the ninth

sternum (Fig. 10), between the first pair and sometimes a little in front of them. The outer pair on segment 9 form the dorsal valvulæ, the inner pair the inner valvulæ, while the pair from segment 8 become the ventral valvulæ. Where styli occur, they may appear at an earlier stage than the papillæ, which are destined to form the valvulæ, and invariably occupy the same position as the outer papillæ of the ninth sternum, so that as these elongate into the valvulæ they carry the styli with them as small apical appendages. The styli, in all Orthopteroid insects, ultimately disappear or become indistinguishable from the apices of the dorsal valvulæ, but in many Odonata, including all the Zygoptera and some of the Anisoptera (Aeshninæ and Petalurinæ of the Aeshnidæ), well-developed styli persist in the adult females as functional organs.

In early larval life, when the first rudiments of the ovipositor appear, the abdominal segments are of relatively uniform size, decreasing in length but little towards the caudal extremity. In forms with a well-developed ovipositor (Orthoptera, Grylloblattoidea, Mantoidea), however, as development proceeds, the tenth segment becomes relatively smaller and the ninth deeper, so that, when maturity is reached, the sternal region of segment nine is shifted from a horizontal to a nearly vertical position, thus bringing the bases of the dorsal and inner valvulæ into the same transverse plane with those of the ventral valves. An enlargement of the bases of the valvulæ usually accompanies their increase in length and this brings about a crowding out, as it were, of such portions of the ninth sternum as are not occupied by the ovipositor itself. Thus, in the adult, the lateral areas are represented merely by the valvifers, while the median parts are the intervalvular membrane and the superior and inferior intervalvulæ.

In contrast to the reduction of the ninth sternum, the eighth sternum is usually prolonged caudad as the subgenital plate covering the vulva and bases of the ventral valvulæ. In some groups (Blattoidea, Mantoidea and Isoptera) it is, however, much reduced and hidden by the greatly developed seventh sternum, which replaces it as a subgenital plate. In such cases the eighth sternum becomes more or less completely dechitinized.

The important question as to the homologies of the valvulæ will be deferred until after the consideration of both the male and female structures in the various groups.

Orthoptera.

Tettigonoidea (Tettigoniidæ).

As the ovipositor and associated parts in this group reach a high state of development and are at the same time of a remarkably generalized type, it seems best to consider it first.

The ovipositor varies enormously in length, form and armature, but with these features we need not be concerned. It will suffice for our purpose to examine one of the more primitive and one of the more specialized types.

Of the genera studied, we have found the most primitive types of ovipositor in the cricket-like forms belonging to the Stenopelmatinæ and Rhaphidophorinæ. The well-known "stone-crickets" belonging to the genus *Ceuthophilus*, of the latter subfamily, illustrate this type well.

In *Ceuthophilus* (e. g. *C. lapidicola* Burm.) (Figs. 1–4), the ovipositor shows comparatively little tendency towards the pronounced lateral compression or blade-like character of the more typical green grasshoppers and katydids. It is subcylindrical in the stouter basal part, becoming more compressed distally. The dorsal valvulæ overlap the other two pairs, completely concealing the inner valvulæ, and there is no tongue-and-groove connection between the dorsal and ventral valvulæ, such an engagement existing only between the ventral and inner valvulæ. The ventral valvulæ are closely applied together, meeting along the mid-ventral line. The basivalvulæ are distinct, though not heavily chitinized and are not wholly concealed by the rather small subgenital plate. Between the basivalvula, ninth tergite and base of the dorsal valvula, is the subtriangular valvifer, the upper angle of which is articulated with the ectal margin of the base of the dorsal valvula. Its antero-dorsal and antero-ventral margins are raised internally into strong ridges, (Fig. 4), the latter being continuous with the intertergal apodeme, which runs for a moderate distance along the front margin of the ninth tergite and terminates abruptly.

The inner edges of the dorsal valvulæ meet at a point near the base, proximad of which they diverge again slightly, but at the extreme base (excluding the superior apophyses) they are closely united by the small triangular superior intervalvula, which, as usual, projects beneath as a median vertical apodeme.

The superior apophyses are triangular processes of average length. The inferior apophyses curve inwards to meet the inferior intervalvula, which is a large, thin, sagittiform plate.

The inner valvulæ are much shorter than the other two pairs and are somewhat widely overlapped by the dorsal valvulæ. The rami are connected across the well-developed intervalvular membrane, a little beyond its middle, by the broad pons valvularum, and are articulated at their bases with the inferior intervalvula behind the inferior apophyses. A portion of the proximal division of the rami is separated from the remainder by a distinct joint. The inner valvulæ are apparently supported by a strong chitinous process projecting inwards from the inner surface of the dorsal valvulæ at point about opposite the posterior limit of the intervalvular membrane.

The ninth and tenth segments are very short and the tenth tergite, as in all the groups of true Orthoptera, does not form a complete ring, there being a distinct though unchitinized sternal area. The eighth spiracle occupies the pleural membrane near the edge of the tergite.

The cerci are long and taper from a stout base to a slender apex. They are unsegmented, but it may be noted that in males of some species of the closely allied genus *Pristoceuthophilus* (e. g. *P. cercalis* Caudell) a few small segments are present at the apices of the cerci. Although this is very probably a caenogenetic character, it is of interest in connection with the other primitive characters met with in the subfamily Rhaphidophorinæ.

As an example of the more specialized type of ovipositor in the Tettigoniidæ, we may take *Conocephalus fasciatus* De Geer (Figs. 5–8). The ovipositor of this species is straight and sword-shaped, the valvulæ being more strongly compressed and closely coherent than in *Ceuthophilus*. Both dorsal and inner valvulæ engage the ventral valvulæ by tongue-and-groove joints, the groove in each case running along the edge of the ventral valvulæ. The basivalvula is not a distinct plate, but there is a flattened ventral area, which is evidently its equivalent. It is but little chitinized, except in its ventrolateral edge. The superior intervalvula is larger than in *Ceuthophilus* and shows a distinct external pocket or invagination and a well-developed median apodeme, extending down-

wards and forwards. It articulates closely with the dorsal valvulæ. The pons valvularum occupies the entire distal half of the intervalvular membrane and is continued cephalad as a slender median process, which meets the under side of the superior intervalvula, but does not fuse with it. In some species, such as *Tettigonia verrucivora,* according to Dewitz ('75)[14], there is an actual fusion with this plate. The inferior intervalvula is a slender transverse bar, whose outer ends are closely articulated with the rami of the inner valvulæ, and less intimately with the inferior apophyses of the superior valvulæ, which terminate beyond the articulation in an upwardly bent spine. The dorsal apophyses are larger than in Ceuthophilus, but not essentially different. The valvifer and intertergal apodeme do not differ materially from those of Ceuthophilus.

The end segments are more elongate than in this genus, the tenth segment and anal valves more prominent. The cerci are shorter and there is a distinct cercal basipodite.

The female genitalia of *Ceuthophilus* may be regarded as somewhat more primitive than those of *Conocephalus* in the following characters: The distinct basivalvulæ, the less compressed ovipositor and the less complete cohesion of the valvulæ due to the absence of the tongue-and-groove joint between the dorsal and ventral valvulæ. The more elongate and flexible cerci might also be included, but it is in the males (*vide postea*) that they show a decidedly more primitive form than in *Conocephalus.*

Finally, it may be added that in the Tettigonoidea in general the supra-anal plate is not divided transversely into two sclerites, as is commonly the case in the females of Acridioidea, i. e., there is no separate eleventh tergite; and it is not always sharply marked off from the tenth tergite. The paraprocts are generally but little chitinized.

Grylloidea (Gryllidæ).

In this group, as in the preceding, the ovipositor is typically long and slender, but, although sometimes compressed and ensiform or falcate, it is usually cylindrical and more or less enlarged apically, the enlarged part armed with teeth. In the Gryllotalpinæ or mole-crickets the ovipositor has wholly disappeared in adaptation to the subterranean habits.

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[14] Dewitz, H., Zeits. wiss. Zool., Bd. XXV, pp. 174–200, Taf. 11, 12 (1875). (*Tettigonia verrucivora* referred to as *Locusta viridissima.*)

We may take as an example of the family the common field cricket (*Gryllus assimilis* Fabr.)

In this species (Figs. 11–15) the eighth and ninth tergites are very short in the mid-dorsal line, but the ninth expands considerably on the sides and extends farther ventrad than the others. The seventh sternum is very large, but is not produced caudad as a free flap, while the eighth sternum forms a small subgenital plate, similar to that of the Tettigoniidæ. The eighth spiracle occupies the pleural membrane close to the tergal margin. The tenth tergite is laterally very short, but is dorsally longer and fused with the supra-anal plate, though the line of fusion is visible. The paraprocts are larger and more heavily chitinized than is usual in the Tettigoniidæ. The cerci are long, flexible and tapering, with numerous hairs and sensillæ, being very similar to those of *Ceuthophilus*, though larger.

The valvifer is very large and is produced under cover of the subgenital plate into a strong process, which probably represents a part of the basivalvula. Its inner surface is without strong marginal ridges, but bears a stout process or apodeme, directed ento-caudo-dorsad. Its antero-dorsal angle is connected, as usual, with the ninth tergal apodeme, which is well developed. There is also a similar but weaker eighth tergal apodeme.

The ventral valvulæ are without distinct basivalvulæ, but these are represented by a well-defined unchitinized area, covered by the subgenital plate, and probably also by the ventral processes of the valvifers.

The dorsal valvulæ are peculiar in the sudden expansion of their bases, this part forming part of the sternal surface rather than the valves themselves. Between these bases and partly fused with them is the relatively large superior intervalvula. Like that of *Conocephalus*, its lower part is deeply depressed and it is also similarly produced cephalad into a thin median apodeme. The superior and inferior apophyses are well developed and the latter are connected by a transverse bar, which represents the inferior intervalvula.

The shafts of the dorsal and ventral valvulæ fit closely together by a tongue-and-groove joint and their enlarged apices are locked together by a peculiar structure, consisting of a projection from the dorsal valvula, which fits into a socket in the ventral valvula.

The inner valvulæ are extremely vestigial and quite membranous. They project backward from the lower part of the superior intervalvula. They were overlooked by Lacaze-Duthiers (loc. cit.), who mistook the dorsal valvulæ for them, owing to their close connection with the inferior intervalvula, which is suggestive of the connection in many Tettigoniidæ between this plate and the rami of the inner valvulæ.

In *Oecanthus* (Figs. 16–18, *Oe. quadripunctatus* Beut.) the genitalia do not differ from those of *Gryllus* except in comparatively unimportant details. The most striking feature is the exceedingly powerful ninth tergal apodeme, which forms a complete arch around the base of the tergite; and the otherwise feebly chitinized dorsal surface of segments 9 and 10. These features are doubtless related to the habit of the genus of ovipositing in woody stems, which would require a greater development of the muscles of the ovipositor than is necessary in such ground-dwelling species as *Gryllus assimilis*.

The dorsal and ventral apophyses and the ventral prolongation of the valvifer are also longer than in *Gryllus*.

The general proportions of the abdominal segments and terminal structures are somewhat suggestive of some *Tettigoniidæ* and of *Grylloblatta*, but there are no indications of relationship with the latter form, as has been more than once suggested by Crampton, who has been apparently influenced by superficial resemblances of form. As far as the terminal abdominal structures are concerned, *Oecanthus* is more specialized than *Gryllus*, and if anything even less like *Grylloblatta* than the latter genus is.

Acridoidea (Acrididæ, Acrydiidæ).

The appearance of the ovipositor in this superfamily is singularly different from that of the two preceding groups, but the fundamental similarity of its structure in all three was demonstrated long ago by Lacaze-Duthiers ('52, *loc. cit.*) and Graber ('70)[15]. Its peculiarities in the Acridoidea are chiefly modifications connected with the different method of oviposition. The dorsal and ventral valvulæ function as a pair of forceps for digging the hole, usually in the ground, in which the eggs are deposited. Each pair of valves acts as one of the

[15] Graber, V., Sitzb. K. Akad. Wiss., Bd. LXI, Abtl. 1, pp. 597–616, 1 Pl. (1870).

blades of the forceps, the movements being in the sagittal plane. The inner valvulæ take no part in this process, but serve to roof over the path along which the eggs are passed out.

As a type of the group we may take the common two-striped locust (*Melanoplus bivittatus* Say.) (Figs. 22–25). In this species the eighth tergite is well developed, but the ninth and tenth are not only greatly shortened, but are fused laterally, the intersegmental furrow being imperfectly developed. The supra-anal plate is divided by a transverse suture, the basal part probably representing the eleventh tergite, while the apical part is the tergite of the anal segment or telson. There is also a distinct cercal basipodite, which may represent a separated lateral portion of the eleventh tergite. The cerci themselves are very short and unsegmented. The paraprocts are broad, flat and well chitinized, and are not completely separated from the tenth tergite at the lateral margin.

The abdominal tergites are in reality pleuro-tergites, since they bear the spiracles, a short distance from their lateral margins. This feature is more pronounced in the Acrididæ than in other families of Orthoptera. The eighth sternum forms a large subgenital plate and terminates in a papilliform process called the "egg-guide," another characteristic Acridian structure.

The ventral valvulæ are short and very stout at base, but taper to a slender decurved hook-like apex. They are peculiar in that the tegument is divided into five distinct sclerites, of which the lateral and the three ventral ones constitute the basivalvula, while the long dorsal one represents the shaft. This is evident by comparison with *Acrydium* in which there are but three sclerites. The dorsal valvulæ are of about the same length as the ventral, and the apices are likewise hook-like, but curved upwards. They are narrowly separated at base, the interval being occupied by the small superior intervalvula, which lacks the usual median apodeme, but has two slight prominences for muscular attachments.

The superior apophyses are represented only by thin flat tendons of the powerful elevator muscles of the dorsal valvulæ. The inferior apophyses (Fig. 24), on the other hand, are stout processes which bend inwards from the base of the valvulæ to articulate with the inferior intervalvula. This plate has the form of a curved bar, from the concave side of which a bifurcate

process arises. The inferior apophyses join the ends of the bar, while the arms of the bifurcate process are connected with the rami of the inner valves. These connections are thus quite similar to those of the Tettigoniidæ (cf. *Ceuthophilus*).

The inner valvulæ are very short, but not vestigial as in the Gryllidæ. They are connected almost to their apices by the intervalvular membrane, the rami being united distally by a V-shaped pons valvularum.

Extending cephalad from the basal articulation of the dorsal and ventral valvulæ into the body-cavity as far as the seventh segment is a somewhat flattened and heavily chitinized rod (pap), which is entirely concealed in an external view. This structure appears as though grooved externally, but the groove is covered over with thin chitin, so that it is really a tubular invagination. It serves for the origin of the most powerful muscles of the valvulæ, i. e., the elevators of the dorsal and depressors of the ventral valvulæ. Its morphological nature has been the subject of differences of opinion. Lacaze-Duthiers (*loc. cit.*) interpreted it as the "épimerite" (valvifer), while Graber (*loc. cit.*) thought it represented the superior apophysis of the dorsal valvulæ. The latter interpretation is obviously incorrect; the former is much nearer the truth. The muscles, which in other Orthoptera arise from the ninth tergal apodeme and its vicinity and are inserted into the superior apophyses, take their origin in the Acrididæ from this rod, the apodeme being undeveloped in its usual situation. It will be remembered that this apodeme is continuous with that of the lower edge of the valvifer in the Tettigoniidæ and other groups, and that it tends to be best developed towards its lower end, where it is sometimes raised into a distinct process (e. g. *Diapheromera, Stagmomantis*). As the muscles which usually connect the valvifer with the superior intervalvula arise in *Melanoplus* also from this process, it appears that the latter represents in part the lower end of the tergal apodeme and in part the valvifer. That it does not represent the main body of the latter is clearly shown by an examination of both nymph and adult of one of the small grouse-locusts (Acrydiidæ, more commonly known as Tettiginæ). Fig. 28 represents the end-segments of the female nymph of *Acrydium ornatum* Say. Here we find a perfectly typical valvifer of considerable size. In Fig. 26, which is taken from an adult *Acrydium*, the valvifer is also

present, but is very small and sub-chitinized. The characteristic rod (pap) is fully developed and is separate from the valvifer, but its base of attachment is in very close relation to the latter; in fact, in an internal view of the nymph, they appear to be in contact with one another.

The first appearance of this rod in the nymph of Melanoplus is a slight invagination of the soft chitin at the angle between the valvular bases. This is later continued cephalad as a thin band-like tube, as seen in the last nymphal stage, assuming its final form only at the last moult. No external appearance of the valvifer is present in Melanoplus.

In respect of the presence of a distinct valvifer in the Acrydiidæ we may consider the latter to be a more primitive family than the Acrididæ and this view is borne out by other features of the terminal segments. In the nymph of *Acrydium*, e. g., the ventral valvulæ possess unmistakable basivalvulæ (bs), which, however, in the adult became divided into two sclerites, a lateral and a ventral, the latter representing the two principal ventral sclerites in Melanoplus. The ninth and tenth tergites are quite separate and less reduced than in Melanoplus, especially in the nymph. The tenth tergite (Fig. 29) is imperfectly divided into median and lateral regions, of which the former is less heavily chitinized and is produced caudad into a lobe which divides the eleventh tergite into two separate lateral plates. The supra-anal plate also shows two lateral chitinized areas. In the nymph (Fig. 29), the eighth and ninth tergites are unmodified, but in the adult they also present a narrow, less densely chitinized median region, which folds inwards, allowing the lateral parts to come together in a pointed or Gothic arch.

These peculiar features are very suggestive of the Tridactylidæ, which also resemble the Acrydiidæ in some other respects. The cerci are divided into a stouter basal part, which is hairy, and a slender smooth apical part. This gives them the appearance as though composed of two fused segments, a feature which is also suggestive of some Tridactylidæ (q. v.).

In other respects the female genitalia closely resemble those of the Acrididæ, the larger size of the superior intervalvula in *Acrydium* as compared with that of *Melanoplus* being perhaps the most striking difference noted.

The eighth spiracle, as in other Acridioidea, is situated in the tergite (pleuro-tergite), but the others retain a more primitive position in the pleural membrane.

Tridactyloidea (Tridactylidæ).

This small family has been commonly associated with the Gryllidæ, owing to the superficial resemblance of the typical genus, *Tridactylus*, to the mole-crickets (Gryllotalpinæ), a resemblance due to the subterranean habits of both. Thus we find in both *Tridactylus* and *Gryllotalpa* a similar form of head and pronotum, short antennæ, front legs adapted for digging and reduction of the ovipositor, which in *Tridactylus* is vestigial, while in *Gryllotalpa* it is entirely wanting. In the Tridactylid genus, *Ripipteryx*, however, which is not a distinctly subterranean form, there is a well-developed ovipositor, and it is not at all like that of a Gryllid, but is remarkably similar to that of the Acridoidea, as suggested by de Saussure and Zehntner ('94).[16] These authors, however, failed to appreciate fully this resemblance and made no comparisons between the two groups.

I have examined the terminal segments and ovipositor of *Ripipteryx forcipata* Sauss. (Figs. 19–21), and find the latter to be closely comparable with that of the Acridoidea, but with certain important features of its own.

The obliquity of tergites 9–11, which is slightly indicated in *Acrydium* and associated with the weakening of the median region and a breaking up of the dorsum into a number of secondary sclerites, occurs in the Tridactylidæ in an exaggerated form. In *R. forcipata* the eighth tergite is normal in shape and form except that it is divided along the mid-dorsal line into two lateral plates, the thin tegument between the plates being folded inwards. This is also the case in a slighter degree in *Acrydium*. The ninth tergite is also completely divided into two lateral plates, but the obliquity has been carried so far that the original anterior, ventral and posterior margins are respectively ventral, posterior and dorsal in position. The antero-dorsal angles of these plates extend forward underneath the eighth tergite as two slender processes, which are apparently all there is to represent the dorsal region. The tenth tergite lies dorsal to

[16] Rev. Suisse de Zool., tome II, Fasc. 2, pp. 403–430, Pls. XVI, XVII (1894).

the ninth, and consists of two narrow lateral plates prolonged forward into a pair of slender, curved bars, which pass between the similar processes of the ninth tergite, under cover of the eighth tergite, but meet in the middle line between the two main parts of the latter and three other small plates which apparently represent the median elongated portion of this tergite in *Acrydium*. The eleventh tergite is possibly represented by the two small oblique plates at the base of the supra-anal plate, and two others laterad of these at the bases of the cerci (cercal basipodites). These relations are also similar to those of the Acrydium. The cerci are short, cylindrical and unsegmented, although in Tridactylus they are distinctly two-segmented, and in certain other species of *Ripipteryx* (*R. mexicana* Sauss.) they are imperfectly divided into a number of secondary segments (de Saussure & Zehntner, loc. cit.).

The supra-anal plate is similar in form to that of Acrydium but is semi-membranous and undivided. It varies, however, considerably in form in different species of the family, as do also the subdivisions of the abdominal tergites, so that it is questionable to what extent these parts are really homologous to those of the Acrydiidæ.

The paraprocts are of very remarkable form, being greatly elongated, with a terminal segment like a pair of styli or a second pair of cerci. These, however, have nothing to do with true styli, for which they were mistaken by Crampton ('18)[17]; for the styli, when present in female insects, are always borne by the dorsal valvulæ or their homologues, and thus belong to the ninth segment. These peculiar structures, which are present in both sexes in *Tridactylus* as well as *Ripipteryx*, were correctly interpreted by de Saussure and Zehntner as outgrowths of the paraprocts.

Another feature possessed by *Ripipteryx* in common with *Acrydium* is the position of the eighth spiracle in the eighth tergite, and the other spiracles in the pleural membranes.

Turning to the sternal region, we find that, except in the case of the eighth, the sternites overlap the tergites instead of vice-versa. The eighth sternum forms the subgenital plate, but is not specially modified for the purpose and lacks an egg-

[17] Bull. Brooklyn Ent. Soc., Vol. XIII, No. 7, Pl. V, Fig. 48, 1918.

guide. The basivalvulæ are of enormous size and have the appearance of a divided subgenital plate, for which they were mistaken by de Saussure and Zehntner.

The ovipositor as already noted, is essentially Acridian in type. The dorsal and ventral valvulæ are sigmoid in form, the apices of the dorsal valvulæ curving upwards, the ventral pair terminating in sharp, decurved hooks, and having also a shorter external hook (cf. *Melanoplus*, Figs. 22, 23). In de Saussure and Zehntner's Figure (l. c., Pl. XVII, Fig. 27) what is evidently the same hook is represented as belonging to the dorsal valvulæ, but this is certainly an error, due to the valvulæ having been tightly closed in the specimen drawn. As in most Acridoidea there is no trace of the valvifer, while the free chitinous rod (pap) is represented by a prominent, shelf-like apodeme (ap 9), extending from the angle between the valvulæ along the ventral edge of the ninth tergite and projecting a short distance under the eighth. This ridge is quite similar in relation to the valvulæ to the free rod of the Acridoidea, but is a true ninth tergal apodeme, like that of the Gryllidæ and Tettigoniidæ. It is in this feature that the genitalia of the Tridactylidæ differ most from those of the Acridoidea.

The dorsal valvulæ, as in the Acridoidea, lack distinct superior apophyses. The superior and inferior intervalvulæ have precisely the same positions as in that group, but are even smaller and simpler in form. The inferior intervalvula is a slender transverse bar resembling that of *Gryllus* in form and is connected at its outer ends, separately, with both the small inferior apophysis and the rami of the inner valvulæ. The latter are, as in the Acridoidea, very small, but lack the intervalvular membrane and pons.

There are many other points of resemblance between the Tridactylidæ and Acridoidea, and taking all these into consideration, we can hardly doubt that the nearest relations of the former are the Acridoidea rather than the Gryllidæ.

Grylloblattoidea (Grylloblattidæ).

The female genitalia of the Orthoptera are most nearly approached by those of *Grylloblatta*, so that we may consider this form next.

A glance at the end-segments and ovipositor of *Grylloblatta* (Figs. 31–35) at once recalls the Orthopterous families Gryllidæ and Tettigoniidæ, except in the segmented cerci, which are more like those of certain Plecoptera, or to a less extent, the Mantidæ. The form of the eighth, ninth and tenth segments is very like that of *Conocephalus*, though more depressed and the tenth segment more prominent. The eighth sternum is not flap-like, but quite generalized in form, although a median pale or thin area is present, which marks the small cavity into which the vagina opens.

The ninth tergite (Fig. 31) is somewhat prolonged ventrad as in *Gryllus*, the ventro-cephalic margin being oblique, as is usual in the Tettigoniidæ and Gryllidæ. The tenth tergite in the adult female is fused with the sternite forming a complete ring, as in many Plecoptera. Its dorsum is slightly prolonged behind the bases of the cerci, but does not overlap the supra-anal plate, which is quite distinct, though small. Both supra-anal plate and paraprocts, which are subchitinized, are quite like those of many Tettigoniidæ. The spiracles, which are very small, are all situated in the pleural membrane.

In the external form of the valvulæ and their connections with neighboring sclerites *Grylloblatta* is remarkably like a primitive Tettigoniid, such as Ceuthophilus. The most conspicuous, but not the most important difference is in the basivalvulæ, which are more clearly defined and more heavily chitinized, recalling those of the Mantids. The valvifer has exactly the same relations as in the Tettigoniidæ. Its lower angle articulates with the ecto-basal angle of the ventral valvula, not being prolonged under the subgenital plate as in *Gryllus* and *Oecanthus*. There are well-marked internal ridges along its upper and lower margins, the latter being continuous with the ninth tergal apodeme, all these features recalling *Ceuthophilus* or *Conocephalus* strongly.

The ovipositor is much like that of *Ceuthophilus* or related genera, though the valvulæ are less compressed and not so closely applied to one another, the ventral ones, particularly,

being slightly separated from one another along the mid-ventral line and from the dorsal valvulæ along their entire length. The dorsal valvulæ do not overlap the ventral valvulæ on the sides, so that the inner valvulæ are not concealed as in the Tettigoniidæ. The inner valvulæ are a little shorter than the ventral, with which they are connected by a tongue-and-groove joint of the same character as in *Ceuthophilus*, i. e., there is a narrow groove with raised edges along the upper margin of the ventral valves, into which fits a ridge along the lower margin of the inner valves.

In order to study the inner connections of the valvulæ the abdomen of the original paratype specimen was cut across at the base of segment seven, and the posterior segments treated with potash.

Fig. 32 shows the ovipositor in dorsal view, with the left ventral valve forcibly turned outwards; the right valve is omitted. The dorsal valves are separate from one another except near the base, where they meet at little more than a point, the inner margins then diverging again. The superior apophyses are very like those of *Ceuthophilus* (Fig. 1) and the articulations with the valvifer quite similar. The inferior apophyses are prolonged inwards into a pair of slender curved bars, which meet one another in the middle line. These evidently represent the inferior intervalvula, but are in no way distinct from the apophyses.

The inner valvulæ fit closely into the concavities of the dorsal valvulæ, there being no space between the two pairs such as we usually find (cf. *Ceuthophilus*). The intervalvular membrane is well-developed as is also the pons which unites the rami just beneath the point where the dorsal valvulæ meet. The median part of the pons projects below from the upper surface, as a bilobed prominence (Fig. 35, pp), which recalls the transverse thickened portion of the superior intervalvula in the Mantids (Figs. 35, 49). No median apodeme could be found, however, and it is to this apodeme that the muscles arising from the valvifers are attached in the Mantidæ, Tettigoniidæ and Gryllidæ. This apodeme, when present, is situated between the valvifers, the muscles running transversely and if such an apodeme were present in this position in *Grylloblatta* it would lie considerably in front of the bilobed prominence.

The fact that the valvifers are well chitinized and bear the usual ridges for muscular attachment seems to indicate, however, that the muscles in question are probably present and yet no sclerite for their inner attachment was found, unless it be the bilobed prominence. As compared with *Ceuthophilus* this prominence would appear to belong to the pons, but in any case it seems probable that the pons was primitively not distinct from the superior intervalvula, as is indeed the case in such forms as the Mantids where no distinct intervalvular membrane is developed. With the great development of this membrane in the Tettigoniidæ, however, the pons became differentiated, retaining its connection with the superior intervalvula in some forms (e. g., *Tettigonia)* while becoming entirely separated from it in others, such as *Ceuthophilus.* Although the matter requires further investigation, it may be considered probable that the superior intervalvula is at least partly represented by the bilobed prominence beneath the pons. If this is the case, *Grylloblatta* differs from all the other forms studied in which the superior intervalvula is present in that this sclerite does not connect the bases of the dorsal valvulæ, but lies beneath them.

The rami of the inner valvulæ are fused with the inferior apophyses which, as stated above, is not distinct from the inferior intervalvula. This firm union of the dorsal and inner valves, together with the manner in which the latter fit closely within the former, would seem to prohibit any independent movements of the inner valvulæ.

A short distance behind the united inferior apophyses is the opening of the receptaculum seminis, a small, thick-walled rounded pouch.

The female nymph—(Figs. 36–38). The only known specimen of the female nymph was recently described by the writer ('19)[18] and is nearly full grown. The eighth sternum is similar to that of the adult, except that it is uniformly, though feebly, chitinized. The ventral valvulæ arise just behind the sternal margin and are straight, subcylindrical processes, bluntly pointed at the apices. The basivalvulæ are clearly defined by a transverse groove. The sternal region of segment nine still has its primitive horizontal position in line with that of segment

[18] Walker, E. M., Can. Ent., Vol. LI, 11, pp. 131–139. 1919.

ten. Across its middle arise the dorsal and inner valves in the same transverse plane. They are likewise of subcylindrical form, the inner valvulæ pointed like the ventral pair, while the dorsal valvulæ have well-developed styli upon their apices, a primitive feature, unlike any of the Orthoptera at so late a stage. Judging by the comparative lengths of the valvulæ the styli evidently go to form the apices of the dorsal valvulæ. There is no trace of the intervalvular membrane, this structure being doubtless formed from the median part of the sternal area, both before and behind the bases of the inner valvulæ. The remaining parts of the sternum go to form the valvifers (antero-lateral region) and the broad bases of the dorsal valvulæ (postero-lateral region).

It will be seen that at this stage the ovipositor of *Grylloblatta* is distinctly more primitive in character than that of a Tettigoniid nymph of corresponding stage. This is seen in the form and position of the valvulæ and in the presence of styli. In these respects they approach the Blattidæ and Mantidæ, but the valvulæ of the ninth segment have not the terminal position, nor have the dorsal valvulæ the broad, flattened form found in these groups. In these respects the Blattids and Mantids are the more primitive and *Grylloblatta* occupies a position between them and the Tettigoniidæ.

Phasmoidea.

In this well circumscribed order the ovipositor is of a somewhat primitive type and is, at the same time, more or less degenerate and probably functionless in most cases. It is generally largely concealed by a hood-like subgenital plate, which as in the Orthoptera, is the eighth sternum. The end-segments (8 to 10) show no tendency to become abbreviated and the sternal surface of segment nine retains its primitive horizontal position in the same plane with that of segment ten. The abdominal spiracles are all situated in the pleural membrane. The cerci are always relatively short and unsegmented and the anal valves (supra-anal plate and paraprocts), though prominent, are not usually large nor densely chitinized.

In the remarkable little Phasmid, *Timema californica* Scudd. (Figs 39, 40), the genitalia appear to be of very primitive form, but they may perhaps be more correctly described as of

a "larval" type, i. e., they are probably to be looked upon as degenerate, functionless structures, whose development has been arrested at an early stage, as is not uncommonly the case in degenerate structures. The eighth sternum is but little produced over the bases of the ventral valvulæ, which are slender and flexible with broader basivalvulæ. The ninth segment is shorter than usual in this order, but the sternum is horizontal, its lateral parts, the valvifers, being larger and having a larval position in relation to the dorsal valves of the ninth tergite. They were erroneously regarded as basal segments of the dorsal valvulæ (basivalvulæ) by Crampton. The dorsal valvulæ are flexible, triangular flaps, whose bases meet the inner edges of the valvifers exactly. The term "dorsal" is here inappropriate, as they retain the larval position external to the inner valves, with which they are fused to within a short distance of the apices of the latter. Neither dorsal nor inner valvulæ are connected with the ventral pair. Having seen only one specimen of *Timema*, which was kindly lent by Prof. Crampton, I have not studied the internal relations of the valvulæ.

The tenth tergite is rather long dorsally, but narrowed ventro-laterally. Its apex is somewhat produced over the supra-anal plate, which like the paraprocts, is rather long and pointed, though but thinly chitinized. The cerci are large and stout.

A less primitive ovipositor, but more typical of the order, is that of the common stick-insect, *Diapheromera femorata* Say. (Figs. 41–43). The valvulæ of this species are of considerable size, but quite soft and flexible. They are flattened dorso-ventrally and arched towards the anus. The inner valvulæ lie as in *Timema* in the primitive position between the dorsal valvulæ (although in some genera they lie dorsal to the latter), with which they are united in a similar manner. This connection seems to be characteristic of the Phasmoids and it was for this reason that the inner valvulæ were mistaken by Lacaze-Duthiers ('52, loc. cit.) for a part of the dorsal valvulæ. There is little development of the intervalvular membrane and the rami are represented only by a short chitinous process on each side, at the angle of union with the dorsal valvulæ, these processes ending freely, there being no trace of either superior or inferior intervalvulæ. The underside of the inner valvulæ bears a very distinct though flexible ridge (Fig. 43), which fits

in a corresponding groove in the ventral valvulæ (Fig. 41), but as the parts are soft no union is thus obtained. The dorsal valvulæ do not lie so flat as in *Timema*, but the primitive widely separated position is retained, their bases not becoming arched dorsad over the inner valvulæ. Their only strongly chitinized parts are the superior apophyses which are well developed and a small process just above the angle with the ventral valvulæ, and apparently representing the inferior apophyses. There is no trace whatever of the valvifer, but there is a small process (pap) which seems to belong to the lower extremity of the ninth tergal apodeme. Both valvifer and apodeme, however, may be well developed in the Phasmoidea as shown by Lacaze-Duthiers in the genus *Acrophylla*. Their absence in *Diapheromera* is a degenerative feature The basivalvulæ are also absent in this genus. The subgenital plate is of large size, but much smaller than in many other genera. The tenth segment is large, with an extensive sternal area, but the supra-anal plate and paraprocts, though prominent are much smaller than in *Timema*. The cerci are also relatively smaller.

There is considerable variation in the Phasmids in the size of the subgenital plate, the relative lengths, form and position of the valvulæ, but a firm, coherent structure, such as the ovipositor of the Orthoptera and Grylloblattoidea, does not, so far as we are aware, occur in this order. The apparently primitive form of the Phasmoid ovipositor may be largely due, as already suggested in the case of *Timema*, to imperfect or arrested development, but at the same time, it is probable that the Phasmoid ovipositor never reached a high degree of development.

Mantoidea (Mantidæ).

Of the single family comprising this order two species were studied, *Stagmomantis carolina* L. and *Mantis religiosa* L. They are so much alike in the parts with which we are concerned, that we may confine our attention in the main to the former, this having been the form which was most thoroughly studied.

In *Stagmomantis* (Figs. 44–49) there is a marked abbreviation of the eighth and ninth tergites, which also extend a shorter distance ventrad on the sides than the seventh and preceding

segments, so that they are separated from their sterna by a wider extent of pleural membrane. The tenth tergite is also laterally reduced, but is prolonged backwards over the supra-anal plate, taking the place of the latter, which is greatly reduced and feebly chitinized, as are also the larger paraprocts. The spiracles are all situated on the tergites, near their lateral margin. The cerci consist of about 15 short segments, which are but little flattened.

The ovipositor is of considerable size, but almost entirely concealed by a huge hood-like structure, which is the seventh sternum and is therefore not the homologue of the subgenital plate of the groups thus far discussed. Under cover of this hood and adherent to it is a bifid plate (Fig. 44), which overlaps the vulva. This is part of the eighth sternum and apparently the homologue of the subgenital plate of the Orthoptera and Phasmoidea. The vulva lies between a pair of median shelf-like valves. Extending forward from between the base of the valves is a thick fold with a chitinized edge (ar), upon which is a small opening of the spermatheca. In the natural position of the parts this orifice lies just above the vulva. The valvulæ are large, but of irregular shape and only partly chitinized. The dorsal pair overlaps the ventral and both are distally decurved and peculiarly lobed at their blunt apices. The ventral valvulæ are widely separated for some distance from their bases, this space apparently serving for the exit of the ova and secretions which form the ootheca. The basivalvulæ are usually distinct and heavily chitinized, being the firmest parts of the valvulæ. Just above the basivalvula is a small, but well-chitinized valvifer connecting the dorsal and ventral valvulæ in the usual way. In Crampton's figure of the ovipositor of *Stagmomantis*[19] this plate is incorrectly labeled "basivalvula" (i. e., of the dorsal valvulæ). It bears only one apodeme, parallel to the antero-ventral margin and continued as a strong ridge across the pleural membrane to the tergites of segments eight and nine, opposite the intersegmental groove, where it is expanded into a short broad spur (pap), and is thence continuous with the short tergal apodemes of these two segments. (Fig. 48). The pleural apodeme is a thickening of the intersegmental furrow, and is marked externally by a distinct groove.

[19] Jour. N. Y. Ent. Soc., Vol. XXV, Pl. XVI, Fig. 7, 1917.

The dorsal valvulæ are close together and at their extreme bases they are joined by a fold of tough cuticle. Just behind this fold is the large superior intervalvula, which unites the two bases closely with one another and with the inner valvulæ. It consists of a stout, bilobed transverse bar connected below with a thin horizontal plate (hlm), which projects forward into the body and bears a median apodeme, which has the same muscular connections with the valvifers as that of the Gryllidæ and Tettigoniidæ.

The dorsal apophyses are short but stout, the ventral rather slender, but well chitinized and firmly united with the large, thin, ventral intervalvula. The inner valvulæ are of moderate length, but very close together, not enclosing a passage for the exit of the eggs. There is a considerable space between their lateral surfaces and the dorsal valvulæ. Like the other valvulæ, they are lobed and ridged, and they engage the ventral valvulæ ineffectively, by a slight tongue-and-groove joint. There is practically no intervalvular membrane and no pons, but the rami are strongly chitinized and fused with the transverse bar of the superior intervalvula. Their anterior extremities, however (Fig. 49), lie below the level of this sclerite on each side of the horizontal plate (hlm) which seems to represent an invaginated intervalvular membrane. There is no connection between the ends of the rami and the inferior intervalvula, such as occurs in the Orthoptera.

A pair of small lobes project back from the inferior intervalvula between the inner valves. (cf. Blattoidea).

Blattoidea (Blattidæ).

In the cockroaches we find many of the peculiarities of the Mantidæ in a more pronounced form, as well as special characteristics of their own. The ovipositor is not only degenerate, but more or less greatly atrophied and completely concealed by the large "subgenital plate," which as in the Mantidæ is the seventh, not the eighth sternum. Crampton (*loc. cit.*, p. 227), states that in the superorder Pandictyoptera, (later termed Panisoptera and including Blattidæ, Mantidæ and Isoptera), "the ventral portion of the terminal abdominal segments is typically overlapped by a backward prolongation of the eighth segment." He considers Holmgren (Termitenstudien. Anat-

omische Untersuchungen, 1909) as being incorrect in designating this segment in the Isoptera as the seventh, believing that the first abdominal segment is not developed ventrally in this order. Allowance is made by Holmgren, however, for the missing segments for the subgenital plate is the sixth sternum by actual count except in some forms where a vestige of the first persists.

This enlarged seventh sternum is prolonged back to the end of the abdomen, thus enclosing a very large "genital cavity" (or "anal cavity," as it is sometimes called), in which the ovipositor is entirely hidden. In some genera such as *Periplaneta* and *Blatta* it bears a pair of apical moveable valve-like plates, which serve to close the opening of the genital cavity.

The eighth and ninth tergites are usually greatly abbreviated and the tenth tergite, though laterally narrowed and not continued inwards beneath the cerci to any extent, is often considerably produced backward between the cerci, overhanging the anus and substituting the supra-anal plate, which in adult cockroaches is wholly wanting. This tenth tergite is commonly termed the supra-anal plate by systematists, but it is better to restrict this term to the structure to which it has been generally applied, otherwise it loses its morphological significance.

The disappearance of the supra-anal plate in the Blattids and its substitution by the tenth tergite is the more complete expression of the same tendency indicated in the Mantids, where the true supra-anal plate, though present, is reduced and entirely covered by the tenth tergum. A similar condition is met with in the Isoptera (q. v.).

The Blattids also resemble the Mantids in having segmented cerci, though these are shorter and more flattened, and in many other respects, which will be noted in the following account.

As an example of a typical Blattid with a fairly well developed ovipositor we may take the common native cockroach, *Parcoblatta pensylvanica* De Geer, better known as *Ischnoptera pensylvanica*. Fig. 52, is an oblique or ventrolateral view of the terminal segments of this species, the seventh sternum ("subgenital plate") having been removed. Fig. 51 is a ventral view of the same parts, omitting those of the tenth anal segments. Fig. 51 is a similar view, but with the valves of the ovipositor forcibly bent forward and the right dorsal valvula cut away from the base.

The ventral valvulæ, like those of the Mantids, are irregular, only partly chitinized and spread apart towards their bases. But here a strange modification is seen. The bases are suddenly enormously expanded and connected with one another by an arcuate, chitinous band, which narrows at the sides and, passing around behind the base, joins a broader plate in this situation. This arcuate band, or its equivalent, varies greatly in form in different Blattids and is clearly the homologue of the transverse sclerite (ar) or chitinous edge of the fold in the Mantids which bears the opening of the spermatheca. It appears to be a special characteristic of these two nearly allied orders. The posterior plates referred to are the basivalvulæ, which have reached this position by the spreading apart of the bases accompanied by an outward rotation. A similar shifting of the valve bases is noticeable in the Mantidæ, but is much less pronounced. In the immature *Parcoblatta*, up to the last instar, no such peculiarities are seen, the ventral valvulæ being close together with typical basivalvulæ, and this simple condition is retained in the adult of *Cryptocercus punctulatus* Scudd. (Fig. 59), the ovipositor in this form having been apparently arrested in development, in a manner closely comparable to that of the Phasmid *Timema californica* (see pp. 292-3).

Immediately behind each basivalvula is the large valvifer, which, as usual, connects the bases of the dorsal and ventral valvulæ and is continuous at its antero-lateral angle with a strong apodeme, which follows the constriction between segments eight and nine to the tergal margins of these segments and is in every way comparable to the similar apodeme in the Mantids. The valvifer is thus widely separated from the tergal margins by a membranous area, which is crossed by the intersegmental apodeme, their relations being essentially the same as in the Mantidæ, and but little different from those which are typical of the Orthoptera, in which the ninth tergal apodeme is really the homologue of the intersegmental apodeme. The longitudinal groove of the apodeme is plainly seen and marks the constriction between the two segments.

Between the valvifers are two large plates which are continuous with the shafts of the dorsal valvulæ, from which they are strongly bent outwards and downwards. These are simply the bases of the dorsal valvulæ, and are not unlike the expanded bases of these structures in *Gryllus*. The dorsal valvulæ are

decidedly folded and irregular on the dorsal side and bilobed at the apices, though ventrally smooth. There is a prominent sub-basal process on the dorsal side (pvd) but it is unchitinized. It is perhaps represented in the Mantids by a minute lateral lobe, which is present in this situation. The expanded bases are united behind by a narrow strip of chitin, in front of which, closely connected with the bases, is the peculiarly shaped superior intervalvula. There is also a pair of short spurs (sap) which may represent the superior apophyses (not present in all Blattidæ) and a pair of slender rods with thin, anterior expansions, (iap), which surround the bases of the inner valves and meet in a somewhat heavier median portion (iv), just behind the ventral valve bases. These rods evidently represent the inferior apophyses, while the thicker median piece is the inferior intervalvula. The spermatheca opens a little behind this plate; in other forms, such as *Blatta*, directly upon it.

The inner valvulæ have much the same form as in *Stagmomantis* and as in this genus they are slender, close together, and lie in the hollow of the dorsal valvulæ, close to the latter and engage the ventral valvulæ very feebly. In their slightly expanded, flexible apices, the lack of a true intervalvular membrane, and the presence of a pair of ventral basal lobes, they also recall the Mantids. They are not fused with the superior intervalvula, however, but are connected with the latter by a peculiar ball and socket joint, the dorsal surface of the fused valve bases bearing a knob, which fits into a socket in the transverse part of the superior intervalvula. In front of the knob the fused valve-bases form a thin plate which is curved upwards (hlm). This plate is similar in position to the plate (hlm) in *Stagmomantis* (Figs. 45, 49) and is doubtless its homologue, as in *Stagmomantis* this plate is likewise continuous with the bases of the inner valvulæ, as well as the superior intervalvula, of which it appears to form a part.

It will be seen from the foregoing description that, in spite of wide differences in the form and proportions of the various parts they are essentially similar in the Blattids and Mantids, the differences being of small weight, as compared with the many points of resemblance.

In addition to the structures described, there is a rather large, though ill-defined chitinized area behind the bases of the dorsal valves (ca), and serving for the attachment of muscles.

This is a secondary deposit of chitin and does not represent a definite sclerite. It is not present in all Blattidæ.

A narrow chitinized strip possibly represents the tenth sternum in *Parcoblatta*. The supra-anal plate is wholly absent in the adult though its vestige is present in the young nymph. The paraprocts, on the other hand, are large, broad and rather flattened and the dorsal surfaces strongly chitinized. The cerci are of the usual Blattid type, the basipodite developed on the inner instead of the outer side.

The immature Blattid (e. g., *Parcoblatta*, Figs. 55–57) is remarkable for the very primitive condition of the ovipositor, which is indicated, (1) by the fact that the valvulæ all develop from the hind margins of their corresponding segments; (2) in the manner in which the dorsal valvulæ develop (*vide infra*); (3) in the broad flat form of their valves, as distinct from the slender inner and ventral valvulæ (cf. the Thysanura, Fig. 72), and (4) in the persistence of styli on the dorsal valvulæ until the last moult.

Development of the ovipositor (*Parcoblatta*). The stages here outlined were first described by Denny ('94)[20] in the case of *Blatta orientalis* L. and are well known, but their significance has not been sufficiently emphasized. Figs 55, 56, 57 and 58 represent ventral views of segments eight and nine, a portion of seven (the seventh sternum being nearly all removed), of three immature stages and the adult *Parcoblatta pensylvanica*. The youngest nymph (Fig. 55) differs little from the male of the same stage except in the presence of a pair of small processes, on the hind margin of the eighth sternum and a small apical median fissure of the ninth sternum. Both sterna are well developed. In the next stage (Fig. 56) the eighth sternum is much narrower; the two little processes are greatly elongated and are marked off from the sternum by a slight constriction. They are now distinguishable as the ventral valvulæ, and the basivalvulæ are also indicated in the median sternal region. The two stylus-bearing lobes into which the sternum is divided have become relatively narrower, and the fissure between them has greatly deepened and widened at base, from which the rudiment of the inner valvulæ have arisen.

[20] Denny, A., Rept. 63, Meeting Brit. Assoc. Adv. Science, p. 818 (1894).

In the third stage (Fig. 57) which represents the last nymphal instar, the eighth sternum is still narrower and has lost its disto-lateral angles. The ventral and inner valvulæ have changed but little, but the two lobes of the ninth sternum have greatly decreased in width, though the styli are practically unchanged. They are now clearly recognizable as the dorsal valvulæ.

The metamorphosis of this primitive condition into the complex structure of the adult is a transformation worthy of a higher order of insects, but the most significant feature in the entire process is the clear indication that the dorsal valvulæ are a part of the ninth sternum, and are homologous with the flat, stylus-bearing sternal lobes or "coxites" of the Thysanura. Their comparatively late development is no objection to their interpretation as such primitive structures, in view of the well-known fact that organs, which are not functional until adult life is reached, are frequently retarded in development.

The ovipositor of *Cryptocercus punctulatus* (Fig. 59) presents an interesting structure intermediate between that of the adult and late nymphal stages of more typical roaches, such as *Parcoblatta*. The ventral and inner valves are quite like those of an immature roach, while the dorsal valves have something of the mature form, but are unusually simple. The valvifer is of remarkably generalised form and together with the well-marked intersegmental apodeme bears a closer resemblance to these structures in the Mantids, than is found in any other Blattid I have examined.

The ovipositor of *Cryptocercus* is, however, very degenerate, the valvulæ and valvifers being very feebly chitinized and their inner connections greatly simplified. Thus, in view of the many details held in common by the more complex types of Blattid ovipositor and that of the Mantids, the simple structure found in *Cryptocercus* must be looked upon as at least partly due to arrested development, or the persistence of a larviform condition, rather than a truly primitive one. It is closely paralleled in the Phasmoidea by *Timema californica*.

It may be added that in certain respects *Cryptocercus* is highly specialized, namely in the enormous development of the seventh tergite, which is prolonged backwards over the remaining segments, so that the latter are completely concealed above and below.

Isoptera.

Two species of this order were examined, *Termopsis angusticollis* Hagen and *Leucotermes flavipes* Kollar. The former is less degenerate in the structure of the genitalia and is therefore more favorable for comparison with other groups, besides being a much larger insect; so that the following remarks, unless otherwise stated, refer to this species.

The abdomen (Figs. 60, 61), is tolerably broad and flattened, not unlike that of a cockroach in appearance, though the tergites are more uniform in size, the eighth, ninth and tenth being much abbreviated only towards the lateral margins. As in the Mantids and Blattids, the tenth tergite is prolonged over the supra-anal plate, which is obsolete in the adult; the paraprocts are broad, subtriangular and more distinctly, though not heavily, chitinized, and the short cylindrical cerci are composed of five segments, of which the apical one is much the longest and is probably compound. *Termopsis* also agrees with these two families in the concealment of the genitalia and sternal regions of segments eight and nine in a "genital cavity," under cover of the backward prolongation of the seventh sternum or "subgenital plate." As mentioned under the account of the Blattoidea, this plate is regarded by Crampton as the eighth sternum, but this is certainly erroneous. If the seventh sternum is cut away, a small chitinized flap is found, overlapping the genital orifice and also covering the bases of a pair of flattened lobes. This flap represents the free edge of the eighth sternum and the two lobes are the ventral valves. On each side of the lobes is a pair of plates, corresponding in position to the valvifers of the cockroach and, like the latter, thickened along the front margin. These plates are evidently the valvifers, the thickening representing the usual apodeme which occurs on the margin. It is not, however, continued laterad of the valvifer, there being nothing here to mark the line of junction of the eighth and ninth sterna.

Behind the overlapping by the ventral valves is a slender V-shaped sclerite. This appears to represent the vestiges of the two slender bars which meet in a similar position in *Parcoblatta* and were interpreted as the inferior apophyses of the dorsal valvulæ, meeting in the inferior intervalvula. They at least represent some part of the bases of the dorsal valvulæ

which have otherwise disappeared, together with the inner valvulæ. The remainder of the ventral surface of segments nine and ten is covered with a thinly chitinized cuticle.

In Fig. 63 the eighth abdominal spiracle may be seen in the conjunction immediately behind the eighth sternum, and close to the lateral margin, a position similar to that which it occupies in *Parcoblatta.*

It is sufficiently evident that the terminal abdominal structures of *Termopsis* are essentially like those of a Blattid in which the ovipositor has nearly disappeared. In *Leucotermes* it has quite vanished and the cerci are reduced to two segments.

Judging by the more uniform length of the abdominal tergites, the cylindrical form of the cerci, and many other characters in other regions of the body it is probable that the ancestors of the Isoptera were more primitive than any Blattoidea of recent age, but the genitalia are distinctly more suggestive of the Blattids than the Mantids, and the wing venation of the primitive New Zealand termite *Mastotermes*, is decidedly more like that of the Blattoidea than the Mantoidea or Protoblattoidea, so that I am inclined to consider the order Isoptera as an offshoot from primitive Blattoid stock.

The results of these studies of the genitalia of the Mantoidea, Blattoidea and Isoptera strongly support Crampton's grouping of these orders in a superorder "Panisoptera."

Dermaptera.

In this order the genital segments are so highly modified that they give little information that is of value in determining the systematic position of the order. While in the majority of forms the ovipositor is entirely lacking, a small one is present in some genera of Protodermaptera, notably in the families Pygidicraniidæ and Echinosomidæ (Zacher, '11),[21] so that we may conclude that the absence of this structure is a secondary condition. I have not seen any of these ovipositor-bearing forms, having, in fact, examined critically only two species of the order, viz., *Forficula auricularia* L. and *Anisolabis maritima* Bon. I have reproduced, however, figures of the ovipositor of *Kalocrania* and *Echinosoma* from Zacher (*loc. cit.*).

[21] Zacher, Friedrich, Zool. Jahrb., Bd. XXX, Syst., pp. 303–400, 80 Figs. (1911).

In *Forficula* (Figs. 62–64) the eighth, ninth and tenth abdominal tergites are fused, but their boundaries are clearly defined. The eighth and ninth tergites are very short and concealed by the much larger, overlapping seventh tergite; while the tenth is also very large, doubtless owing to the great development of the muscles concerned in the movement of the large forcipate cerci. The eighth and ninth sterna are concealed by the very large seventh sternum, and this feature, together with the reduction of segments eight and nine and the atrophy of the ovipositor is very suggestive of the "Panisoptera" (Blattoidea, Mantoidea and Isoptera); but unlike these groups, the tenth tergite does not replace the supra-anal plate, which is entirely free, and although small, is heavily chitinized and divided transversely into two separate sclerites, the distal of which is situated ventrally between the bases of the cerci, with which it is articulated. Possibly these two sclerites represent the eleventh tergite and the true supra-anal plate, as in the Acridoidea. Where three such sclerites are present (Pygidicraniidæ, Allosthetidæ, *teste* Zacher) they have been interpreted as representing the tergites of as many segments, viz., the eleventh, twelfth and thirteenth, or anal segment (pygidium, metapygidium and telson, or supra-anal plate), but the evidence for the existence of an additional segment between the eleventh and anal segments is quite insufficient. It is worthy of note, however, that these three sclerites are thus separately developed only in primitive genera.

Apart from the features mentioned above, there appears to be no evidence of close relationship between the Dermaptera and the Panisoptera.

The eighth and ninth sterna in *Forficula* are feebly chitinized and each is divided into two lateral plates, which were considered by Verhoeff ('03)[22] to represent coxites. It is probable, however, that this division of the sterna is related to the former presence of an ovipositor, which occupied the median space, and this view is supported by the presence of an ovipositor in this situation in such genera as *Kalocrania* and *Echinosoma*, as judged by Zacher's figures. In these genera the ovipositor consists of but two pairs of valvulæ, belonging to the eighth and ninth segments. The former pair is long and slender

[22] Verhoeff, H. W. Nova Acta. Acad. Caes.-Leop., Vol. XXXI, 1903, pp. 277–278.

and obviously represents the ventral valvulæ. The other pair, from its lateral position and comparatively broad form is doubtless the dorsal valvulæ. Since the dorsal valvulæ represent the coxites of segment nine, the divided sternal plates, which are also present cannot be correctly termed coxites. They are more nearly comparable to the valvifers.

In some genera, such as *Anisolabis* (Fig. 65) there is also a small paired tenth sternum, but this is absent in *Forficula.* The two large sub-triangular plates (Figs. 66, 67), which are closely united with the margins of the tenth tergite and form part of the articulation with the cerci, were regarded by Verhoeff and Zacher as the coxites of segment ten, while Crampton identified them with the paraprocts. Crampton's view is the more probable in my opinion. Coxites are absent from segment ten in all other primitive insects, so that on *a priori* grounds we should not expect to find them in the Dermaptera. Paraprocts, on the other hand, are almost invariably present, and although these plates appear to belong to segment ten, there is no reason why, in such a highly modified group as the Dermaptera, they should not have been developed from the paraprocts, as these are usually closely connected with the margins of the tenth tergite, as, e. g., in the Blattoidea.

The spiracles all occupy the pleural membrane, the last pair, as in all the groups discussed, belonging to the eighth segment.

The unsegmented form of the cerci has probably been developed within the course of evolution of the order, as in immature stages of certain primitive forms (*Diplatys*, *Karschiella* and *Bormansia*) they are segmented.

Embiidina (Embiidæ).

This small group, which is undoubtedly of ordinal rank, has been considered by some writers (Enderlein and others) to be nearly allied to the Isoptera, while others (Crampton, Westwood, MacLachlan) find closer relations with the Plecoptera and Dermaptera. The latter view, is in the present writer's opinion, much nearer the truth. The resemblance to the Isoptera is largely due to the retention in both groups of many primitive characters and to parallel development along certain lines, such as the form and venation of the wings, the two-

jointed cerci, the loss of the ovipositor, etc., but the special features of each group indicate a different line of descent.

As regards the female genitalia, but little evidence in support of either view is obtainable from this source alone. In *Embia major*, e. g., (Fig. 68) the general appearance of the terminal segments is much like that of a termite. The cerci are two-jointed as in most termites, the tenth tergite is large and curves downward, covering the supra-anal plate, to which it is adherent. On the other hand, there is no extension of the seventh sternum to form a subgenital plate, in fact, no modification of either seventh or eighth sterna, and no lateral reduction of tergites eight, nine and ten as in the Isoptera. The paraprocts are large, but unchitinized and are distinct from the well-developed cercal basipodites.

Whereas in *Termopsis* there is evidence that the Isoptera are descended from ovipositor-bearing ancestors, there is no indication in *Embia* or any of the *Embiidina* that an ovipositor was ever present, the eighth and ninth sterna being quite simple. Since an ovipositor of primitive form is present in some Apterygota (*Machilis*, *Lepisma*, etc. of the Thysanura) and is undoubtedly homologous with that of Pterygote insects, it must have been present in the earliest representations of the latter, unless we are to regard the ovipositor-bearing Thysanura as descended from winged forbears, a view which I believe few will accept. This being the case, the Embiids, Plecoptera, etc., must likewise, (contrary to Crampton's opinion) be considered as secondarily without ovipositors. The fact that *Campodea* and other *Thysanura* have also no ovipositor does not affect the question. There is evidence that some of the Palaeodictyoptera had no ovipositor, while it is certain that some of them had one, and it was probably among the former that the ancestors of the Embiids and Plecoptera existed. The ovipositor, which was probably never highly differentiated, had already disappeared before these groups had acquired independent ordinal rank.

It is scarcely profitable to make a comparison between the Embiids and Grylloblatta until the structure of the male genitalia has been considered, but the following characters held in common between the females of the two orders may be mentioned: (1) There is no reduction in the length of the eighth and ninth tergites; (2) the spiracles are all situated in the

pleural membrane; (3) neither the seventh nor the eighth sterna are prolonged into a sub-genital plate; (4) the cerci are segmented; (5) the paraprocts are feebly chitinized. The last feature has no special significance; the others indicate the primitive nature of both groups, but are otherwise negative in value, when taken alone.

No relationship to the Dermaptera or Orthoptera is even hinted at in the terminal abdominal segments of the females of Embiids.

Plecoptera.

As Crampton and others have pointed out, this order is in some respects the most primitive of existing Pterygote insects, particularly in the cervical and thoracic sclerites, wing venation and cerci. In the abdominal segments, of which ten are well developed, there is a tendency in many forms towards a considerable degree of chitinization of the pleural membrane. The ninth and tenth segments may be quite ring-like, even in the adult, while in the nymph all the segments may be annular. Crampton's suggestion that this annular form of segment may be a primitive one seems to me untenable. It is too exceptional among the Tracheata, and even within the Plecoptera there are all grades of chitinization of the pleural membrane. It is moreover, explained by the non-functional character of the abdominal spiracles in the nymph, in which respiration is performed by the tracheal gills, these structures sometimes (e. g., *Pteronarcys*) persisting in the adult in a reduced form.

The abdominal spiracles are all pleural in position, the eighth sternum is frequently more or less prolonged to form a subgenital plate, sometimes overlapping the ninth, or even the tenth, sternum. In some forms (e. g., *Megarcys signata* Hagen)[23] it is bilobed or bifid at apex, these lobes being slightly suggestive of vestigial ventral valvulæ. In most species of *Pteronarcys* there is no backward extension of the eighth sternum as a whole, but it bears a pair of slender processes, at or near the hind margin, which are probably true representatives of these valvulæ, being very similar to these structures as met

[23] Klapalek, Fr., Coll. Zool. Selys., Fasc. IV, p. 12, Fig. 6 (1912). Smith, Lucy Wright; Trans. Am. Ent. Soc., Vol. XLIII, pp. 433–489, Pls. XXIX–XXXIV (1917).

with in certain Libellulid dragonflies. There is no other trace of the ovipositor in the Plecoptera, so far as I am aware, the ninth sternum being quite simple.

The tenth segment is well developed, often little smaller than the ninth. The tergite is often somewhat prolonged behind, concealing or partly covering the small supra-anal plate, with which it may be adherent. The paraprocts are large, generally well chitinized and usually intimately fused with the bases of the cerci so that the latter appear to arise from them. The cercal basipodites are thus not distinct from the paraprocts.

The cerci are typically multiarticulate, but are very variable in respect to both the number and the form of the segments.

These characters, taken by themselves, do not throw much light on the affinities of this group, but point to a very generalized structure, with secondary loss of the ovipositor. The primitive multiarticulate cerci are approached by those of the Grylloblattoidea, more closely than any other order, with the possible exception of some of the Ephemerida.

Ephemerida.

Although the Ephemerida and Odonata can hardly be called "Orthopteroid" insects, and their lines of descent from the Paleodictyoptera are undoubtedly quite distinct from any of the others considered, they deserve a few words, on account of their having retained certain very primitive characters.

The females of Ephemerida are chiefly remarkable from the fact that the oviducts open separately, and behind the seventh, instead of the eighth sternum. In some forms the seventh sternum is prolonged backwards into a spout-like structure, which apparently functions as an ovipositor (Morrison, '19)[24] but this, of course, has no homology with any part of the Orthopterous ovipositor. The elongate, uniformly segmented abdomen, multiarticulate cerci and cerciform caudal filament, borne by the eleventh tergite are all marks of primitive structure. The anal valves are membranous and very slightly developed.

[24] Morrison, Emily Reed, Can. Ent., Vol. LI, No. 6, pp. 139–146 (1919).

Odonata.

The form of the terminal segments of the dragonflies recalls the Phasmids, as suggested by Crampton, there being no abbreviation, but on the contrary, an elongation of all of them, as compared with the usual conditions. A fully developed ovipositor is present in all of the suborder Zygoptera and some of the Anisoptera (Aeshnidæ:—Aeshninæ and Petalurinæ), while a more or less reduced and simplified one occurs in the other groups. This ovipositor is remarkable in several ways. The dorsal valvulæ are broad, subtriangular, hood-like at the apices, and form a pair of flaps or covers for the ventral and inner valves, these structures serving as the actual instrument for making the punctures or incisions in which the eggs are placed. They thus resemble closely the broad sternal processes of segment nine in *Lepisma*, *Machilis* and other Thysanura, which cover over the two pairs of valvulæ (representing the ventral and inner pairs) in quite a similar manner. They are still more interesting in the fact that they retain the styli in adult life as functional sense-organs, the Odonata being the only Pterygote order in which this is the case.

The ventral valvulæ also possess well developed basivalvulæ, the dorsal valvulæ superior and inferior apophyses. A superior intervalvula and intervalvular membrane are also present, but no inferior valvula, the strong rami of the inner valvulæ being articulated with the inferior apophysis.

There is also a valvifer, having typical connections with the valvulæ and ninth tergal apodeme.

The occurrence of these features in the Odonata is of interest in showing that they must be characters of very ancient origin and are in no way specially characteristic of Orthopteroid groups.

SUMMARY OF CHARACTERISTICS OF THE ORDERS.

Based on the Terminal Abdominal Structures of the Females of Types Examined.

Orthoptera—Eighth sternum more or less modified as a subgenital plate, but leaving ovipositor exposed; ninth sternum vertical or nearly so; valvifers (sometimes absent) in contact with ninth tergum and its marginal apodeme; ovipositor well developed (rarely vestigial or absent), with three pairs of valvulæ; basivalvulæ rarely well developed; a superior intervalvula connecting bases of dorsal valvulæ, which cover inner valvulæ and have two pairs of apophyses (superior sometimes indistinct or absent); inner valvulæ, when not vestigial, with rami, intervalvular membrane and pons, the rami with longitudinal ridge which fits into groove on ventral valvulæ; an inferior intervalvula connected separately with rami and inferior apophyses; tenth sternal region not defined, unchitinized; cerci unsegmented (two-segmented in Tridactylus); supra-anal plate well developed, sometimes fused with but not concealed by tenth tergite; paraprocts usually well developed.

Nymph: Valvulæ all slender, dorsal and ventral pairs developing from ventral surface of ninth sternum; styli rarely distinct and usually disappearing at a very early stage.

Grylloblattoidea—Eighth sternum unmodified in form, ovipositor exposed; ninth sternum, valvifers and ninth tergal apodeme as in the Orthoptera; ovipositor well developed, with three pairs of valvulæ; basivalvulæ exposed, heavily chitinized, superior intervalvula absent; dorsal valvulæ covering inner pair; both pairs of apophyses present, inferior apophyses joining one another medially, there being no separate inferior intervalvula; inner valvulæ well developed, with rami, intervalvular membrane and pons; rami fused with inferior apophyses and connected with ventral valves as in Orthoptera; tenth segment annular; cerci, slender eight-segmented; supra-anal plate small, but not concealed by tenth tergite; paraprocts not large, unchitinized.

Phasmoidea—Eighth sternum modified, usually forming a very large flap-like subgenital plate, largely concealing the ovipositor; ninth sternal regional horizontal; valvifers and

ninth tergal apodeme variable in development; ovipositor generally of considerable size, but the three pairs of valvulæ not firmly chitinized; dorsal valvulæ widely separated at base, not covering the inner pair and without a superior intervalvula; superior and inferior apophyses present, the latter widely separated; inner valvulæ united dorsal except distally and having sometimes an ineffective tongue-and-groove connection with ventral valvulæ; no intervalvular membrane or inferior intervalvula; tenth segment with distinct sternal region; cerci short, unsegmented; supra-anal plate usually small, paraprocts prominent.

Mantoidea—Tergites of segments eight and nine shortened; seventh sternum forming a very large subgenital plate concealing remaining sterna and ovipositor; eighth sternum greatly reduced; ninth, vertical or subvertical; valvifers separated from tergites, but connected across intervening membranous area by the intersegmented apodeme with eighth and ninth tergites; ovipositor of considerable size with three pairs of valvulæ, basivalvulæ heavily chitinized, widely separated, but connected by a chitinous arch or transverse bar; valvulæ of irregular form, and imperfectly chitinized; dorsal valvulæ covering inner pair, united at extreme base; superior intervalvula connecting both dorsal and inner valvulæ; dorsal valvulæ with two pairs of apophyses, the inferior apophyses joined by a large inferior intervalvula; inner valvulæ free from the latter without intervalvular membrane, but the internal (basal) prolongations of the rami connected by a thin plate which bears the median apodeme of the superior intervalvula; ventral valvulæ engaging inner by a feeble tongue-and-groove joint. Cerci subcylindrical, many-segmented; supra-anal plate vestigial, concealed by tenth tergite; paraprocts little chitinized.

Nymph (*Mantis*) similar to that of Blattoidea, but styli in last stage very minute.

Blattoidea—Abdominal segments flattened; tergites of eight and nine shortened; seventh sternum forming a very large subgenital plate, concealing remaining sterna and ovipositor; eighth sternum greatly reduced; ninth obliquely inclined; valvifers very large, separated from tergal margins, but connected across intervening membranous area with the eighth and ninth tergites by the intersegmented apodeme; ovipositor small, the three pairs of valvulæ of irregular form, more or less

imperfectly chitinized and not coherent, though an ineffective engagement between the ventral and inner valves may occur; basivalvulæ very widely separated and rotated outwards, connected in front by a chitinous arch or bar; dorsal valvulæ covering inner pair, their bases greatly expanded, and medially united; superior intervalvula connected with dorsal valvulæ and with lamella formed by united bases of inner valvulæ, which are free from ventral valvulæ and lack an intervalvular membrane; inferior apophyses represented by slender bars connected with a vestigial inferior intervalvula; cerci of moderate length, flattened, segmented; supra-anal plate absent in adult, being substituted by tenth tergite; paraprocts flattened, generally well chitinized in part.

Nymph with valvulæ terminal, dorsal pair broad and flat, retaining styli until last stage; a vestigial supra-anal plate present.

Isoptera—Abdominal segments somewhat flattened; seventh sternum forming a large subgenital plate, covering the remaining sterna; eighth sternum ill-defined and greatly reduced; ninth, oblique or almost horizontal; valvifers, when present, widely separated from tergites, the intervening space not crossed by an apodeme; ovipositor absent or represented by a very reduced pair of ventral valvulæ and traces of the bases of the dorsal valvulæ; tergites eight, nine and ten laterally narrowed, the tenth replacing the supra-anal plate, which is absent in the adult; paraprocts broad, somewhat chitinized; cerci short, slender, with 2–5 segments.

Dermaptera—Tergites of segments eight and nine greatly abbreviated and concealed by the seventh, tenth very large; seventh sternum forming a subgenital plate and concealing eighth and ninth sterna, which are medially divided; ovipositor usually absent, when present, reduced and lacking inner valvulæ; ventral valvulæ long and slender, dorsal valvulæ shorter and broader; tenth sternum sometimes represented by a pair of small sclerites; cerci very large and strong, forcipate, unsegmented (except in larvæ of some genera); supra-anal plate terminal, exposed, heavily chitinized, divided into pygidium and telson, sometimes with an intervening metapygidium; paraprocts ventral, consisting of flat, well-chitinized plates.

Embiidina—Segments seven to nine unmodified, there being no specialized subgenital plate; ovipositor wholly absent; supra-anal plate practically absent, replaced by the large tenth tergite; paraprocts lobate, unchitinized; cerci two-jointed.

Plecoptera—Eighth sternum generally more or less modified to form a subgenital plate, sometimes with a pair of lobes or processes, possibly representing vestigial ventral valvulæ; ovipositor otherwise absent; ninth sternum horizontal, unmodified; ninth and tenth segments tending to be annular; supra-anal plate variable, sometimes covered by a prolongation of the tenth tergite; cerci typically long and many-jointed, their basal segments fused with the large paraprocts.

Comparison of Ovipositors of Pterygote and Apterygote Insects.

In the Apterygota the ovipositor is present only in the families Machilidæ and Lepismatidæ of the order Thysanura. It consists of two pairs of filiform gonapophyses, arising from the eighth and ninth sternum respectively. In *Machilis* sp., e. g., the separated eighth sternum has the appearance shown in Fig. 74. It is deeply bilobed, each lobe bearing a stylus while the gonapophyses occupy a median position between the lobes. They are very long and flexible and are divided by faint constrictions with numerous segments, with regularly arranged groups of setæ. The ninth sternum (Fig. 75) is similar to the eighth, except that the styli and sternal lobes are much longer, while the gonapophyses are shorter and more slender. In the natural position they reach about the same distance back. As compared with the eighth and ninth sterna, the preceding sterna (Fig. 73) differ not only in the absence of gonapophyses, but in the union of the stylus-bearing lobes and the presence of a triangular basal plate (ste), these parts being separated only by sutures. They also differ in the presence of eversible glands (cgl).

It is now generally recognized that the basal plate is the true sternite, while the lateral styli-bearing plates are *coxites*, these probably representing flattened coxæ of abdominal limbs which have otherwise disappeared (Haase, '89).[25] The sterna of

[25] Haase, Erich, Morph. Jahrb., Vol. XV, pp. 331–435, Pls. XIV, XV (1889); Verhoeff. Zool. Anz., Vol. XXVI, pp. 60–77 (1903).

segments eight and nine in *Machilis* are thus composed chiefly of the coxites, the sternite having practically disappeared. In some of the Lepismatidæ, however, (*Nicoletia*, *Atelura*) (Escherich, '05)[26] the ninth segment has a distinct sternite overlapping the bases of the coxites just as in the thoracic segments. Comparing the eighth and ninth sterna of *Machilis* with those of the immature Blattid (Figs. 56–59) we have no difficulty in recognizing the coxites of segment nine in the flat stylus-bearing lobes, which become the dorsal valvulæ, and the gonapophyses of the same segment in the inner valvulæ of the Blattid, while the gonapophyses of segment eight in *Machilis* are the homologues of the ventral valvulæ of the Blattid. The styli of the latter segment have disappeared and the coxites are fused with the sternite, to form a "coxosternum" (Verhoeff, loc. cit.). It may be added that in *Machilis*, *Lepisma*, etc., the coxites of segment nine overlap the gonapophyses, forming a sort of sheath for them, just as they do in such Odonata as have retained a well-developed ovipositor. In *Aeshna*, e. g., (Fig. 71), the "genital valves" are the coxites of segment nine or dorsal valvulæ, and although more complex in form they have a very similar general position to those of Machilis, covering the other valvulæ in the same way, and bearing styli at their apices. There is no part of the anterior gonapophyses of *Machilis* that is distinctly recognizable as the basivalvulæ."

The homologies of the terminal abdominal structures of the female with those of the male, and other general questions will be discussed in Part II.

[26] Escherich, K. Das System der Lepismatiden, Zoologica, Bd. 18, Heft 43, pp. 1–164, 11 Pls. and 67 text figures (1905).

EXPLANATION OF PLATES.

Reference Lettering.

ap 8, 9—apodeme of segment 8 or 9.
ar—basal arch.
bc—basipodite of cercus.
bs—basivalvula.
c—cercus.
cf—caudal filament.
clg—coxal gland
cx—coxite.
eg—egg guide.
ga—genital aperture or vulva.
hlm—internal lamella joining bases of inner valvulae.
iap—inferior apophysis.
int ap—intersegmental apodeme.
im—intervalvular membrane.
iv—inferior intervalvula.
lb—inferior lobes of inner valvulae.
p—pons valvularum.
pa—paraprocts.
pap—process of intersegmental apodeme.
pp—ventral prominence of pons.
pvd—sub-basal process of dorsal valvula.
rm—rami of inner valvulae.
sa—supra-anal plate.
sap—superior apophysis.
sp—spiracle.
spth—aperture of spermatheca.
st—sternum, sternal region.
ste—sternite.
stl—stylus.
sv—superior intervalvula.
tg—tergite.
vd—dorsal valvula.
vf—valvifer.
vi—inner valvula.
vv—ventral valvula.

Plate XX.

1. *Ceuthophilus lapidicola*, adult; lateral view of end segments and ovipositor, ventral and inner valvulae bent downwards.
2. Same, not quite mature; dorsal view of ovipositor, left ventral valvula bent outwards, right not shown.
3. Same, adult; ventral view of ovipositor.
4. Same, inner view of structures at base of ovipositor.
5. *Conocephalus fasciatus*, adult; lateral view of end segments and basal part of ovipositor.
6. Same; ventro-lateral view.
7. Same; dorsal view of superior intervalvula and basal connections of inner valvulae.
8. Same; anterior view of base of ovipositor.
9. Same; ventral view of end segments of nymph four mm. long.
10. Same; same view of nymph five mm. long.

Plate XXI.

11. *Gryllus assimilis*, adult; lateral view of end segments and base of ovipositor.
12. Same; ventro-lateral view.
13. Same; dorsal view of ovipositor, left ventral valve bent outwards, right not shown.
1 . Same; inner view of structures at base of ovipositor, left side.
15. Same; anterior view of base of ovipositor.
16. *Oecanthus quadripunctatus*, adult; lateral view of end segments and base of ovipositor.
17. Same; inner view of structures at base of ovipositor, left side.
18. Same, nymph; ventral view of end segments and ovipositor.
19. *Ripipteryx forcipata* Sauss., adult; lateral view of end segments and ovipositor.
20. Same; dorsal view.
21. Same; ventral view.

Plate XXII.

22. *Melanoplus bivittatus*, adult; postero-lateral view of end segments and ovipositor.
23. Same; postero-dorso-lateral view of cleared preparation.
24. Same; posterior view of ovipositor, with valvulae forced widely open.
25. Same; ventral view of ventral valvulae.
26. *Acrydium ornatum*, adult; lateral view of end segments and ovipositor.
27. Same; dorsal view.
28. Same, nymph; lateral view.
29. Same, nymph; dorsal view.
30. Same, adult; ventral view of ventral valvulae.

Plate XXIII.

31. *Grylloblatta campodeiformis*, adult; lateral view of end segments and ovipositor.
32. Same; ventral view.
33. Same; dorsal view of ovipositor, left ventral valvula bent outwards, right not shown.
34. Same; inner view of structure at base of ovipositor, left side.
35. Same; anterior view of base of ovipositor.
36. Same, nymph; lateral view.

Plate XXIV.

37. *Grylloblatta campodeiformis*, nymph; ventral view of end-segments.
38. Same with ventral valvulae bent forward to expose inner valvulae.
39. *Timema californica*, adult; ventral view of end segments.
40. Same, lateral view.
41. *Diapheromera femorata*, adult; ventro-lateral view of end segments.
42. Same; lateral view of ovipositor; most of the 9th tergite cut away to show the superior apophysis.
43. Same; dorsal view of ovipositor.

Plate XXV.

44. *Stagmomantis carolina*, adult; 8th sternum and ventral.
45. Same; dorsal view of ovipositor, with dorsal valvulae spread apart.
46. Same; ventral view of ovipositor with ventral valvulae spread apart.
47. Same; lateral view of terminal segments and ovipositor with 7th sternum bent downwards to expose the valvulae.
48. Same; inner view of structures at base of ovipositor.
49. Same; anterior view of base of ovipositor.

Plate XXVI.

50. *Parcoblatta pensylvanica*, adult; ventral view of ovipositor, the left ventral valvula cut off at base.
51. Same; the valvulae bent forward to show their dorsal surfaces and the right dorsal valvula removed.
52. Same; ventro-lateral view of terminal segments, the 7th sternum removed.
53. Same; ovipositor removed, cleared, and viewed from above. The ventral valvulae and the dorsal valvulae, except their bases, are omitted.
54. Same, last nymphal stage; ventral view of end segments with the 7th sternum except a small part, removed.

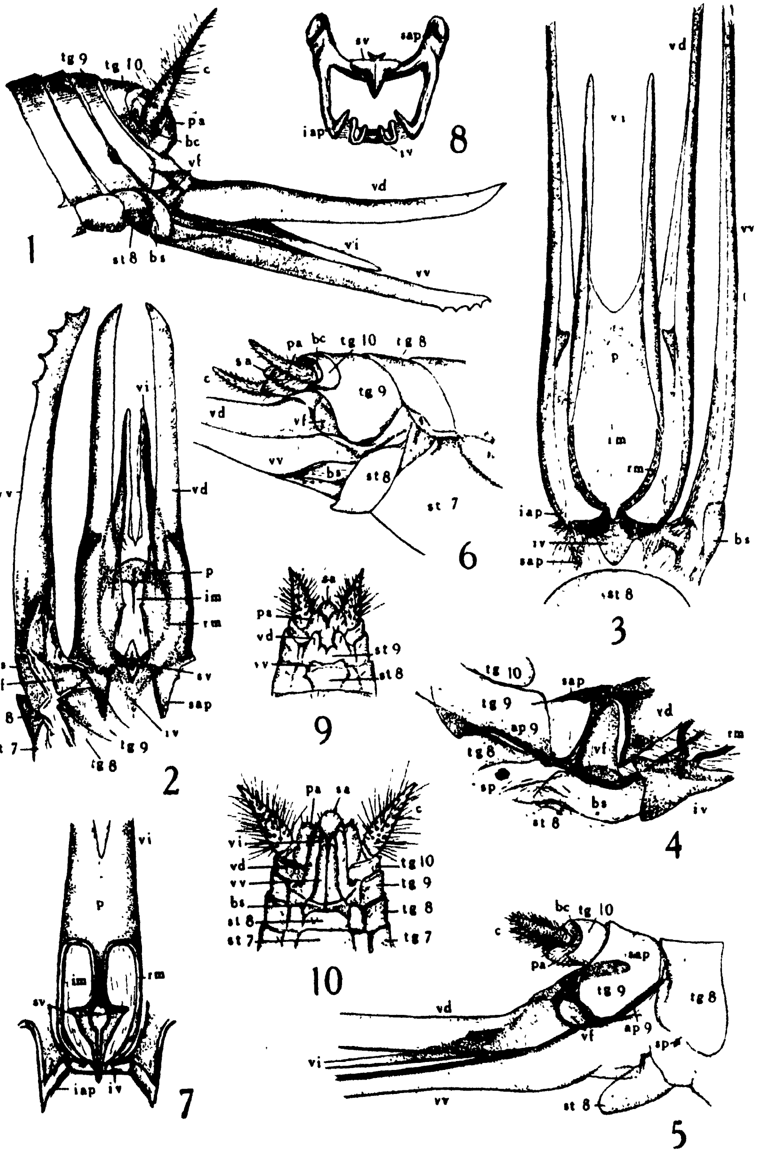
55 to 58. Same; successive stages in the development of the genitalia, ventral view, 7th sternum removed, cerci 10th and anal segments omitted. Fig. 58 is from the adult.

Plate XXVII.

59. *Cryptocercus punctulatus*, adult; ventral view of end segments, the 7th sternum removed.
60. *Termopsis angusticollis*, adult; lateral view of end segments.
61. Same; ventral view of end segments, the 7th sternum removed.
62. *Forficula auricularia*, adult; lateral view of end segments.
63. Same, dorsal view.
64. Same, ventral view, 7th sternum removed.
65. *Anisolabus maritima*, adult; ventral view of end segments, the 7th sternum removed.
66. *Kalocrania marmoricrura*, adult; ventral view of ovipositor and neighboring sclerites. (After Zacher.)
67. *Echinosoma occidentale*, adult; ventral view of ovipositor and part of segment 10. (After Zacher.)

Plate XXVIII.

68. *Embia major*, adult; lateral view of end segments.
69. *Pteronarcys proteus*, adult; ventral view of end segments. (After Smith.)
70. *Perla lycorias*, adult; ventral view of end segments.
71. *Aeshna canadensis*, adult; ventral view of end segments.
72. *Machilis* sp., adult; ventral view of end segments.
73. Same; 8th sternum and gonapophyses (ventral valvulae).
74. Same; 9th sternum and gonapophyses (dorsal and inner valvulae.)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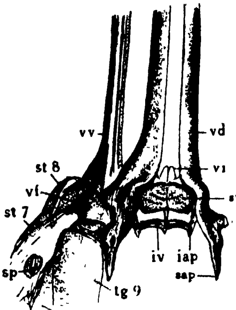

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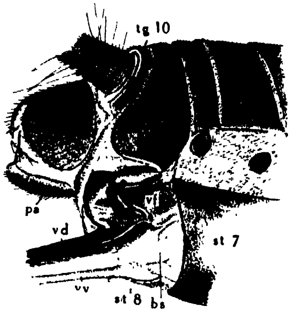

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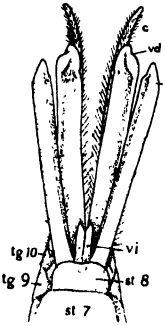

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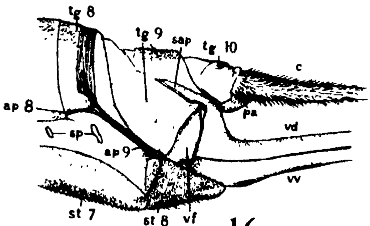

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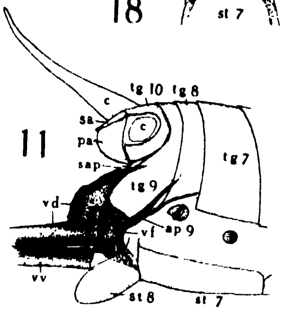

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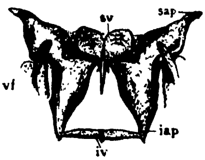

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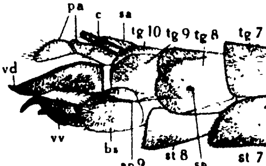

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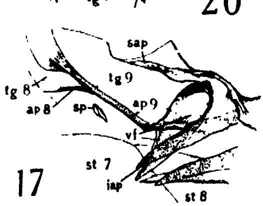

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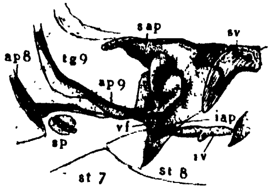

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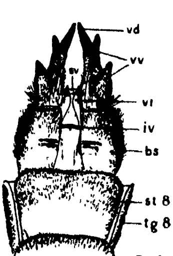

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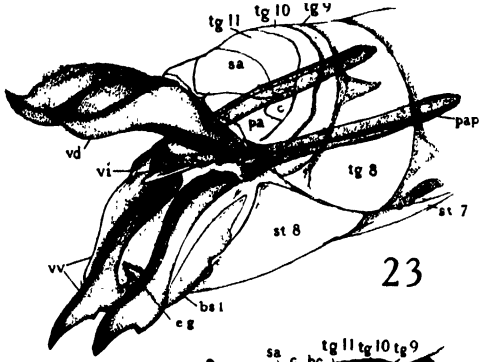

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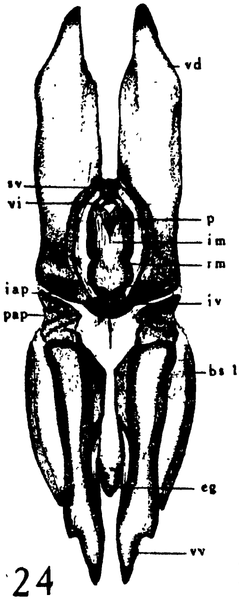

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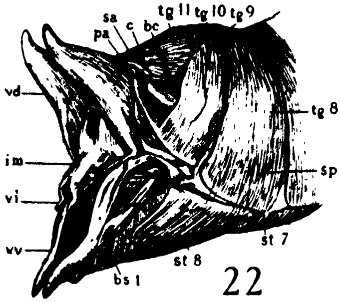

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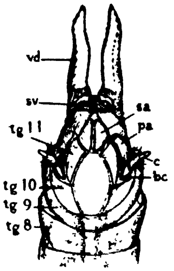

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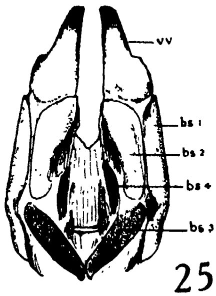

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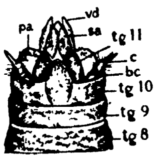

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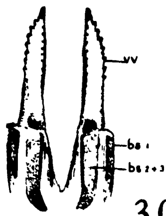

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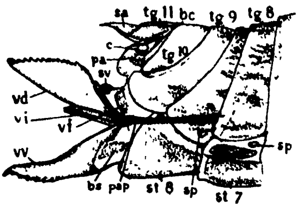

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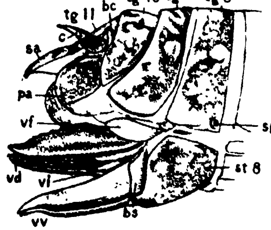

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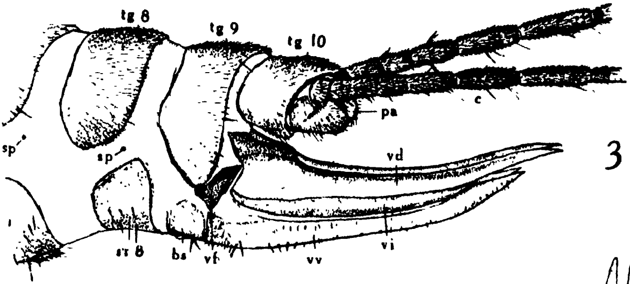

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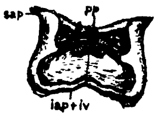

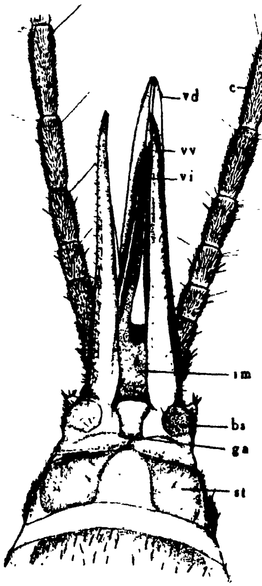

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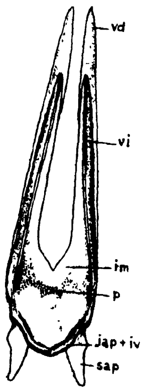

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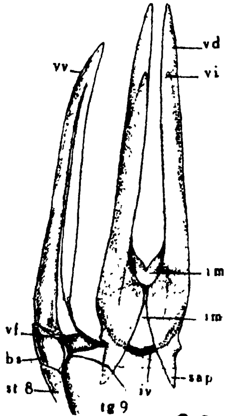

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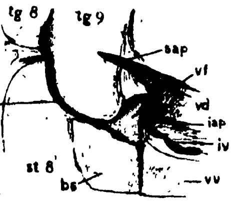

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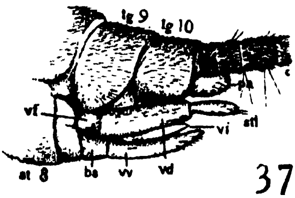

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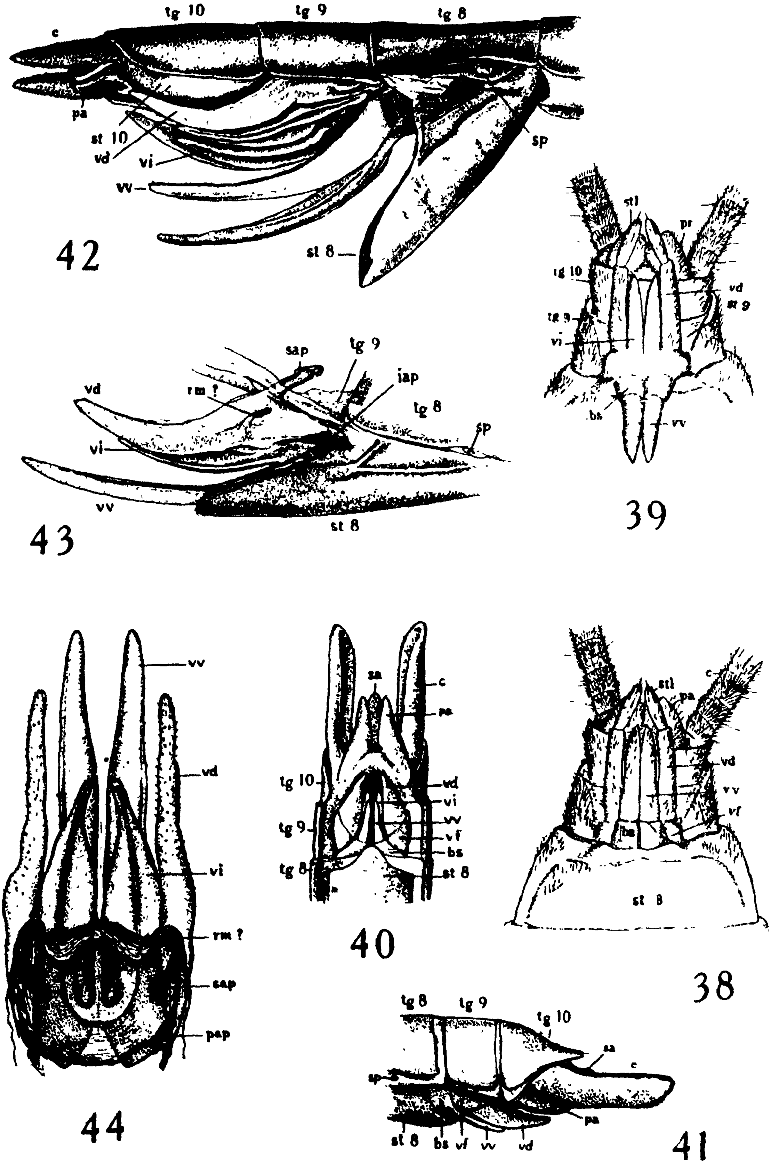
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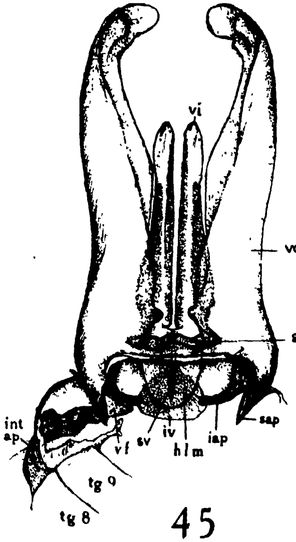

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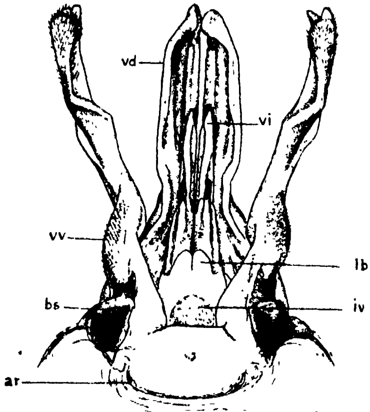

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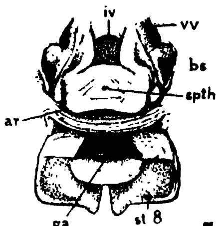

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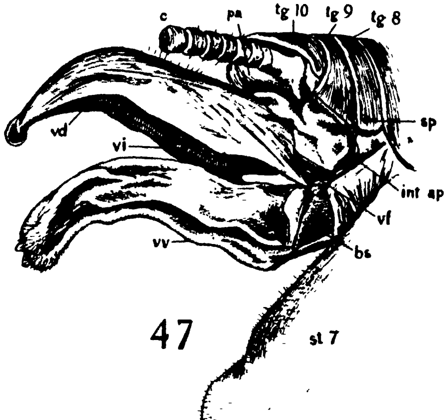

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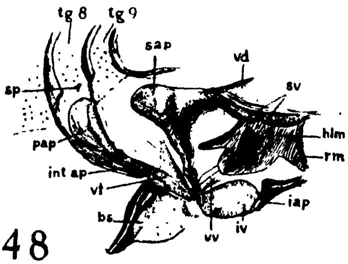

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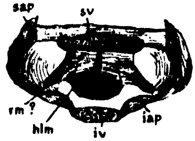

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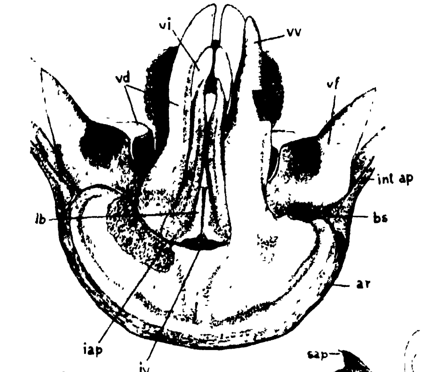

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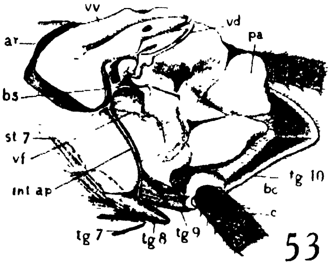

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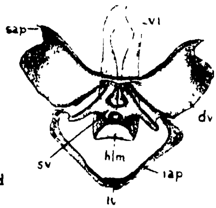

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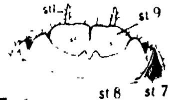

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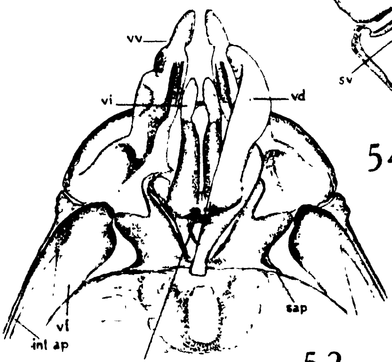

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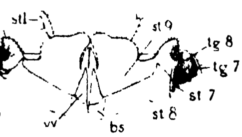

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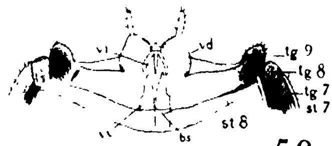

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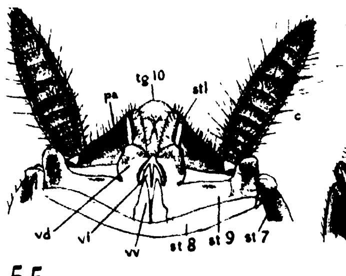

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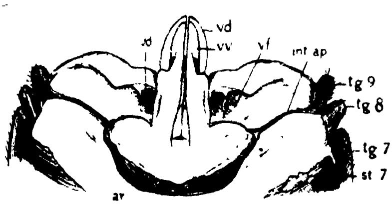

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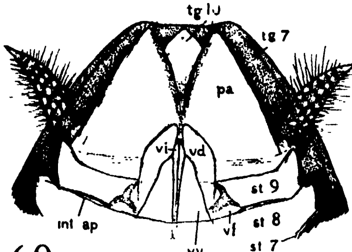

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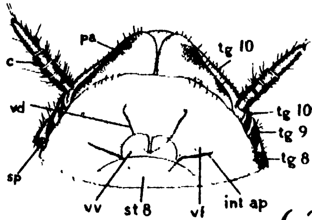

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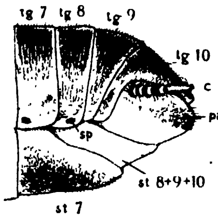

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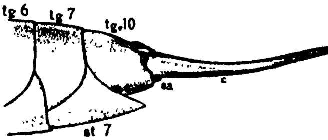

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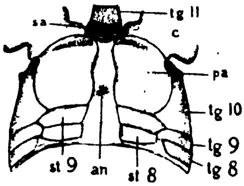

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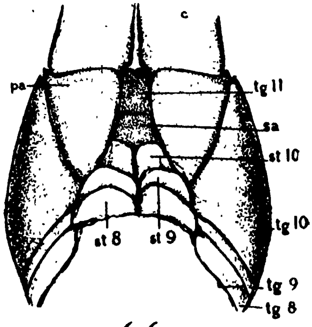

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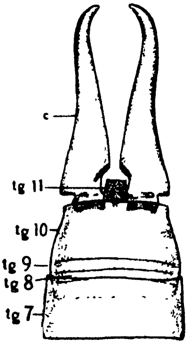

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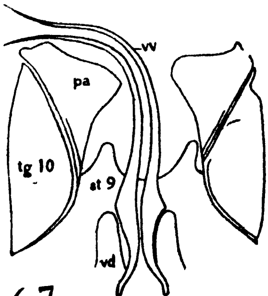

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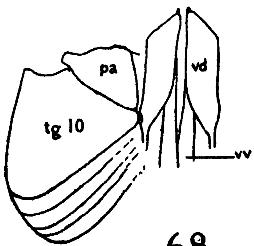

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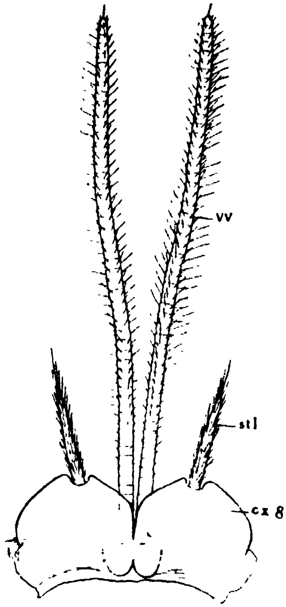

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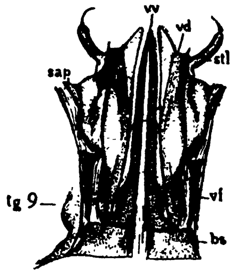

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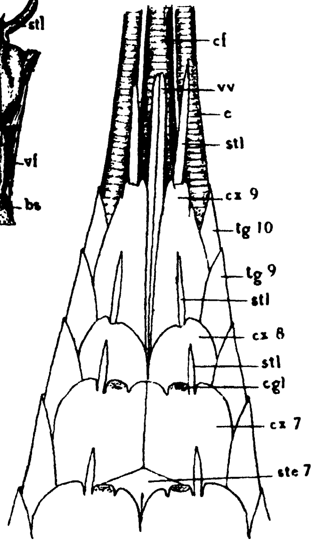

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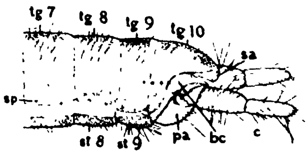

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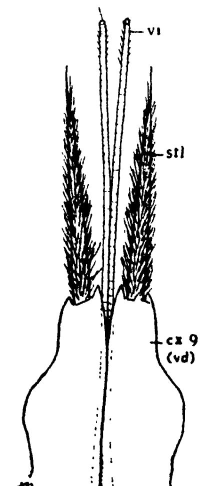

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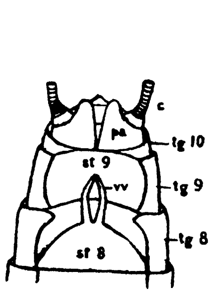

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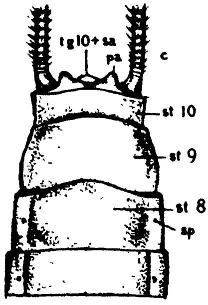

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UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES. (TIPULIDÆ, DIPTERA)

By CHARLES P. ALEXANDER, Ph. D.

The species of crane-flies herein described as new were included in some extensive and highly interesting collections made in the vicinity of Tokio by Mr. Ryoichi Takahashi, during the years 1918 and 1919. The station "Saitama," refers to Chichibu, in the province of Saitama, a mountainous locality about fifty miles from Tokio. The types are preserved in the collection of the author. I am greatly indebted to Mr. Takahashi for this very valuable series of Japanese Tipulidæ.

Dicranomyia Stephens.

Dicranomyia immodestoides sp. n.

Resembles *D. immodesta* O. S. (Eastern North America); antennæ dark brown throughout; general coloration light gray; wings nearly hyaline, stigma pale; veins Sc_1 very long, abdomen dark brown, indis tinctly ringed with yellow.

Male—Length, 5.8 mm.; wing, 6.6 mm.

Female—Length, 6.8 mm.; wing, 7.4–8.3 mm.

Rostrum reddish brown; palpi dark brown. Antennæ with the scape brownish black, the basal flagellar segments brown, the apical segments darker. Head light yellowish gray; the front and the vertex adjoining the inner margin of the eyes bright silvery.

Mesonotum dull gray, the praescutum with an indistinct median brown stripe; lateral stripes indistinct; humeral areas a little more reddish; scutum reddish gray, the lobes largely brown; scutellum reddish gray; postnotum gray. Pleura light gray, indistinctly marked with darker beneath the wing root. Halteres rather long, pale, the knobs dark brown, the base of the stem more yellowish. Legs with the coxæ and trochanters yellow, the former very sparsely gray pruinose, the fore coxæ dark basally; femora dull brownish yellow, somewhat darkened on the apical half; tibiæ and tarsi brown. Wings nearly hyaline, the stigma large, oval, very pale brown; veins slender, brown. Venation: Sc_1 ending opposite origin of Rs, Sc_2 far before the tip of Sc_1, the latter being longer than the basal deflection of Cu_1; r arcuated, at the tip of R_1; cell *1st* M_2 open by the atrophy of m; basal deflection of Cu_1 at or before the fork of M.

Abdominal tergites dark brown, the segments laterally at the base and on the caudal margin dull yellow; sternites nearly similar, the bases of the segments likewise yellowish. In the female the bicolored

condition of the abdomen is not so evident as in the male. Male hypopygium with the ninth tergite deeply notched medially, the adjacent lobes evenly rounded, setigerous; dorsal pleural hook moderately long, at the tip suddenly narrowed into a slender point; ventral pleural appendage large, fleshy, the proximal basal portion produced into a fleshy lobe that bears two erect chitinized spines on its caudal face.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 1, 1919 (R. Takahashi).
Allotopotype, ♀, March 31, 1919.
Paratopotypes, 6 ♂ ♀'s, March 25–May 26, 1919.

Dicranomyia basifusca sp. n.

Antennæ black throughout; thorax gray, the praescutum with an indistinct median brown stripe; wings pale gray, the stigma and a rounded spot at the base, brown; *Sc* ending a little beyond the origin of *Rs*, cell *1st* M_2 closed.

Female—Length, 4.8 mm.; wing, 6.4 mm.

Rostrum and palpi dark brownish black. Antennæ black throughout, the basal flagellar segments short-oval, the terminal segments a little more elongated. Head gray, the front more tawny.

Mesonotum dull gray, the praescutum more brownish medially to form an indistinct dorsal stripe; scutellum and postnotum lighter gray. Pleura dark gray. Halteres yellow, the knobs dark brown. Legs with the coxæ brownish yellow, darker basally; trochanters dull yellow; femora dull brownish yellow, darkened toward the apices, the extreme tips pale; tibiæ yellowish brown, the tips narrowly darker brown; tarsi dark brown. Wings with a faint grayish tinge, the stigma short-oval, brown; a conspicuous rounded brown spot at the arculus; origin of *Rs* and the cord very indistinctly seamed with darker. Venation: Sc_1 ending slightly beyond, Sc_2 exactly opposite, the origin of *Rs;* *Rs* angulated to almost square at origin; cell *1st* M_2 long, closed, about equal in length to the veins issuing from it; basal deflection of Cu_1 at the fork of *M*.

Abdomen dark brown. Ovipositor reddish, the tergal valves very slender.

Habitat: Japan.
Holotype, ♀, Meguro, Tokio, April 10, 1919 (R. Takahashi).

Dicranomyia atripleura sp. n.

Head light grey; mesonotum brownish grey, the praescutum with three pale brown stripes; thoracic pleura with a dark brown longitudinal stripe; legs pale brown; wings greyish subhyaline, stigma rounded, brown; *Sc* short, cell *1st* M_2 closed, about twice as long as vein Cu_1 beyond it.

Female—Length about 6.3 mm.; wing, 6.5 mm.

Rostrum and palpi brown. Antennæ with the scapal segments pale brown; flagellum broken. Head light grey.

Pronotum brownish grey. Mesonotal praescutum pale brownish grey, with three pale brown stripes, the median stripe broad, the lateral stripes indistinct; scutum pale, the lobes darker; scutellum and postnotum heavily light grey pruinose, the latter with a darker median line. Pleura pale, yellowish grey pruinose; a broad, very conspicuous, dark brown stripe, extending from the propleura to the base of the abdomen, passing above the fore coxæ and beneath the halteres. Halteres pale yellow basally, the knobs dark brown. Legs with the coxæ and trochanters pale yellow; femora and tibiæ pale brown; tarsi darker brown. Wings greyish subhyaline; stigma rounded, brown; veins dark brown, *C*, *Sc* and the veins at the wing-base more yellowish. Venation: *Sc* short, Sc_1 ending a little beyond the origin of *Rs*, Sc_2 exactly at the origin; *Rs* less than twice the deflection of R_{4+5}; *r-m* about equal to *m*, a little shorter than *r;* cell *1st* M_2 long, about twice the section of Cu_1 beyond it; basal deflection of Cu_1 immediately before the fork of *M*.

Abdomen dark brown, the sternites more yellowish brown. Ovipositor with the tergal valves slender, strongly upcurved; sternal valves straight, the tips subacute.

Habitat: Japan.

Holotype, ♀, Choshi, Chiba, October 17, 1919, (R. Takahashi).

Dicranomyia mesosternata sp. n.

Antennæ dark brown; head dark; mesonotum brownish black, the pleura gray pruinose; wings pale gray with four brown costal marks and pale gray clouds along the cord and at the ends of the veins; Sc_2 apparently lacking.

Female—Length, 7.3–8 mm.; wing, 8–8.4 mm.

Rostrum and palpi dark brown. Antennæ dark brownish black throughout, the flagellar segments elongate-oval, with rather long verticils. Head dark brownish gray. Vertex very narrow between the large eyes.

Pronotum conspicuous, brown, narrowed anteriorly. Mesonotal praescutum shiny brownish black, the humeral regions with a paler brown pollen; remainder of the mesonotum brown, the scutal lobes brownish black. Pleura shiny dark brownish black, light gray pruinose, most heavily across the dorsal edge of the mesosternum, which is shiny blackish between the fore and middle coxæ. Halteres with the base of the stem pale, the knobs dark brown. Legs with the coxæ yellowish brown, darkest on the fore coxæ; trochanters dull yellow; femora brown, paler basally, the tips dark brown; tibiæ and tarsi dark brown. Wings pale gray, with a heavy dark brown and brownish gray pattern, as follows: four large brown areas along the costal margin, the first at

the arculus, the third at the tip of Sc_1 and the origin of Rs, the last being the stigmal blotch; wing-apex darkened; large, pale brownish gray clouds along the cord, outer end of cell *1st* M_2 and at the ends of the longitudinal veins; veins dark brown. Venation: Sc short, Sc_1 ending opposite or slightly beyond the origin of Rs, Sc_2 lacking; a supernumerary cross-vein at about midlength of cell Sc, located in the second anterior brown blotch; Rs about two and one-half times as long as the basal deflection of R_{4+5}; cell *1st* M_2 closed; basal deflection of Cu_1, before, at or slightly beyond the fork of M.

Abdominal tergites dark brown, the sternites paler brown. Male hypopygium with the ninth tergite broad, the caudal margin gently concave. Ninth pleurite short; ventral pleural appendage pale, the proximal face produced into a stout beak, set with two widely separated spines, one subapical, the other basal. Gonapophyses a little longer than half the length of the penis-guard, slender and gently curved.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, October 20, 1919, (R. Takahashi).

Allotopotype, ♀, July 9, 1919.

Paratopotypes, 4 ♂'s, October 20–21, 1919; 1 ♀, 1 sex uncertain, July 12, 1919.

One paratype bears the label, "This insect was flying about over a stream."

Antocha Osten Sacken.

Proantocha, subgen. n.

Antennæ short, the flagellar segments oval, the terminal segment nearly as long as the preceding two taken together. Head very small, broad, the small eyes protuberant, widely separated both above and below. Thorax very large, the mesonotum convex. Halteres short. Legs very stout, the fore and middle legs covered with conspicuous long erect hairs, the posterior tibiæ with numerous tiny black spines; the coxæ, especially the posterior ones, very large and globular, the hind trochanters being long, narrow, compressed; hind legs very long, especially the tibia, which is slightly curved before its tip; at the base on the ventral face a long, slender spine which meets a similar but stouter tubercle located near the apex of the femur; tarsi remarkably shortened, especially those of the hind legs where they are less than one-fourth the length of the tibia; claws long and straight, at about mid-length with a long straight tooth that is about two-fifths the length of the apex of the claw alone, an additional tiny basal tooth. Venation as in the subgenus *Antocha*. Abdomen short.

Type of the subgenus—*Antocha* (*Proantocha*) *spinifer* sp. n. (Japan).

The genus *Antocha* has, till now, been one of the most compact genera in the Tipulidæ. The discovery of *Antocha spinifer* renders it necessary to subdivide the group. This latter is a curious fly with long, stout, very hairy legs that suggests in its general appearance a *Trimicra* or an *Empedomorpha* rather than an *Antocha*. The venation alone is normal for this latter genus. The discovery of the immature stages of this isolated, generalized fly will possibly result in giving generic rank to the group here proposed.

Antocha (Proantocha) **spinifer** sp. n.

Size very large (wing of male over 12 mm.); legs very long and stout, the fore and middle legs provided with long, dense hairs, the hind tibiæ set with numerous tiny spines and with a large spinous tubercle on the ventral side near the base.

Male—Length about 9 mm.; wing, 12.3 mm. Fore leg, tibia, 7.8 mm.; tarsus, 4.8 mm.; middle leg, tibia, 7.4 mm., tarsus, 3 mm.; hind leg, tibia, 13.8 mm., tarsus, 3 mm.

Rostrum short, dull yellow; palpi short, brownish yellow, the terminal segments more infuscated. Antennæ with the scape and basal three or four segments of the flagellum dull brownish yellow, the remainder of the antennæ brown. Head dull yellow, very sparsely light gray pruinose.

Mesonotum dull brownish yellow, the praescutum darker brown medially, the lateral margins pale. Pleura dull yellow. Halteres pale, the knobs slightly brownish. Legs with the coxæ and trochanters dull yellow; remainder of the legs dull brownish yellow, only the terminal tarsal segments brown; the long, dense hairs that cover the fore and middle legs are dark brown and obscure the ground color of the sclerites that bear them. The hind legs are covered with numerous blackened spinous setigerous tubercles. Claws very long, dark brown, longer than the fourth and nearly as long as the fifth tarsal segment. Wings milky white, stigma indistinct, faintly yellowish; veins brown, the costa beyond the point of insertion of *Sc* tawny and somewhat incrassated. Venation: *r* tending to be obliterated by atrophy; basal deflection of Cu_1 far before the fork of *M*.

Abdominal tergites brownish buff, with a distinct dark brown median stripe that is interrupted at the posterior margins of the segments; sternites reddish, on the terminal segments darker, brownish, the caudal margin of the segments broadly pale.

Habitat: Japan.

Holotype, ♂, Saitama, June 1, 1919 (R. Takahashi).

Antocha (Antocha) **satsuma** sp. n.

Head rusty brown; thorax gray, the praescutum with three brown stripes; wings milky gray, the stigma dark brown; veins *Sc*, R_1 and *C* beyond the stigma chestnut brown; basal deflection of Cu_1 before the fork of *M*.

Male—Length, 5.3–5.5 mm.; wing, 7.3–7.6 mm.

Female—Length, 6.8 mm.; wing, 8 mm.

Rostrum pale reddish brown; palpi dark brown. Antennæ brown, the flagellar segments a little paler basally; scapal segments large, tumid. Head pale rusty brown, with a faint bronzy tinge.

Pronotum grayish yellow, broadly dark brown medially. Mesonotal praescutum grayish yellow with three broad dark brown stripes, the median stripe broadest, not attaining the anterior margin of the sclerite; scutum gray, the lobes dark brown medially; scutellum and postnotum gray. Pleura yellowish gray. Halteres very pale yellow. Legs long and slender, the coxæ pale, sparsely gray pruinose; trochanters dull yellow; femora pale brown, more yellowish basally; tibiæ and tarsi pale brown. Wings milky gray, pale at the base, the stigma dark brown; slightly darker clouds along veins *Rs* and *2nd A* and at the wing apex; veins dark brownish black, *M* and *Rs* pale basally; *Sc*, R_1 and costa beyond Sc_1 light chestnut brown. Venation: *Rs* long and straight, the base rather indistinct; *r* opposite *r–m;* basal deflection of Cu_1 far before the fork of *M*, this distance variable; cell *1st* M_2 small.

Abdomen dark brownish gray, the sternites paler medially, in the female the posterior half of the intermediate abdominal segments is slightly paler than the basal half. Male hypopygium yellowish, the pleurites rather stout; the two pleural appendages are slender, subequal in length, the dorsal hook chitinized, at the tip narrowed into a slender point; ventral pleural appendage fleshy with scattered setæ that are larger and stouter at the tip of the organ. Gonapophyses long, acicular, almost straight, the tips acute.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 21, 1919 (R. Takahashi).
Allotopotype, ♀, March 25, 1919.
Paratopotype, 2 ♂'s, March 26–April 23, 1919.

Dicranoptycha Osten Sacken.

Dicranoptycha yamata sp. n.

Antennæ black, the scapal segments dull yellow; general coloration gray, the praescutum with three brownish stripes; legs black, the bases of the femora narrowly yellowish; abdomen dark brownish black.

Female—Length about 11 mm.; wing, 12.7 mm.

Rostrum and palpi black. Antennæ with the scapal segments dull brownish yellow, the second segment brightest; flagellum black, the base of the first segment paler. Head light gray.

Pronotum brownish gray. Mesonotal praescutum dull gray, clearer anteriorly, with three slightly darker brownish stripes; remainder of the mesonotum clear light gray, only the scutal lobes a little darker. Pleura gray. Halteres yellow. Legs with the coxæ grayish, the mesocoxæ more yellowish; trochanters yellow; femora dark brownish black, the bases narrowly yellow; remainder of the legs dark brownish black. Wings with a strong grayish yellow tinge, somewhat darker distally, the costal and subcostal cells clearer yellow; veins *C* and *Sc* yellow, the remaining veins dark brown. Venation: *Rs* strongly arcuated at its origin, a little longer than cell *1st* M_2.

Abdomen dark brownish black. Ovipositor with the tergal valves flattened, the outer faces with numerous erect yellow setæ.

Habitat: Japan.

Holotype, ♀, Meguro, Tokio, April 23, 1919 (R. Takahashi).

Paratopotypes, 2 ♀, April 24–May 5, 1919.

One specimen bears the label "in a pine forest."

Paratropeza Schiner.

Paratropeza flavitibia sp. n.

General coloration metallic blue; legs yellow, the femora clavate, with a broad black subterminal ring; tibiæ with the tips blackened, the posterior tibiæ with an apical fringe of erect black hairs; metatarsi yellow, darkened at the tips; wings with three broad dark brown cross-bands.

Female—Length, 6.3 mm.; wing, 4.7 mm. Fore leg, femur, 2.9 mm.; tibia, 2.6 mm.; hind leg, femur, 4 mm.; tibia, 3.3. mm.; tarsus, 2.4 mm.

Description from an alcoholic specimen.

Rostrum and palpi pale brown, the terminal segments of the latter about one-half longer than the third segment. Antennæ brown, the second scapal segment and the base of the first flagellar segment more yellowish; flagellar segments oval. Head dark metallic blue.

Thorax metallic blue, with only the dorso-pleural membranes whitish. Halteres dark brown, the knobs whitish. Legs with the coxæ metallic blue on their outer faces; trochanters yellowish brown; fore femora dark brown, more yellowish on the basal half, the extreme tip and a very indistinct band at about one-third the length dull yellowish; middle and posterior femora yellow with a broad dark brown subterminal ring; tibiæ yellow, more brownish basally, the tips broadly dark brownish black, broadest on the hind legs; metatarsi yellow, only the tips brown; remaining tarsal segments dark brown; on the posterior metatarsi the brown tips occupy one-third of the total length. The legs are provided with flattened scales; the femora are strongly clubbed, especially the posterior femora; the posterior tibiæ with a broad apical fringe of outspreading black hairs. Wings hyaline, with three broad brown cross bands, the first proximad of the origin of the sector, extending from the costal to the posterior margin; the second band occupies

the cord; the third the wing apex; costal and subcostal cells brownish yellow; a small brownish spot at the origin of the sector, sometimes confluent with the basal crossband. Venation: almost exactly as in *P. ornatipennis* (de Meij.); *Sc* short, Sc_1 extending to about two-fifths the length of *Rs*, Sc_2 being proximad of the origin of the latter.

Abdomen dark metallic blue; ovipositor yellowish corn color, the sternal valves darker; tergal valves strongly curved.

Habitat: Japan:

Holotype, ♀, Chichibu, Province Saitama, October, 1918 (R. Takahashi).

Edwards (Ann. Mag. Nat. Hist., ser. 8, vol. 17, p. 356; vol. 18, p. 249; 1916) records this new species from Idzu, Japan (June, 1910), but does not give it a name. *P. flavitibia* is closest to *P. ornatipennis* (de Meij.) but is sufficiently distinguished by the broad complete basal wing band and the different leg pattern. The brush of erect or nearly erect hairs at the tips of the posterior tibiæ is very conspicuous and suggests the condition found in the recently described *P. pennipes* (Brunetti) of India (Records Indian Mus., vol. 15, p. 308, 1918; as *gymnastes*). This fly differs from *flavitibia* in the pattern of the legs and wings.

Ormosia Rondani.

Ormosia diversipes sp. n.

Belongs to the *nigripila* group; general coloration black, including the femora, the tibiæ and tarsi abruptly light yellow; wings gray, the stigma brown, the costal margin with yellowish pubescence; anal veins divergent.

Male—Length, 4–4.3 mm.; wing, 5.1–5.5 mm.

Rostrum and palpi dark brownish black. Antennæ with the basal four or five segments yellowish brown; remainder of the flagellum dark brown; flagellar segments (in the male sex) elongate-cylindrical, with abundant erect whitish pubescence that is little shorter than the length of the segment that bears it. Head dark.

Pronotal scutellum pale. Mesonotal praescutum blackish with a heavy reddish brown pollen, the dorso-median area darker, producing an indistinct stripe. Pleura shiny blackish; a brush of more than a score of long erect yellowish hairs on the pleura between the bases of the wings and halteres. Halteres light yellow. Legs with the coxæ dark brownish black, sparsely pruinose; trochanters dull yellowish brown; femora black, a little lighter basally; tibiæ and metatarsi abruptly light yellow, the tips narrowly darkened; remainder of the tarsi dark brown. Wings gray, the stigma more brownish, the costal region more yellowish; base of the wing and an indistinct area near the fork

of *M* pale; veins brown; wings broad, densely covered with hairs. Venation: Cell *1st* M_2 small, closed; basal deflection of Cu_1 slightly before the fork of *M;* anal veins strongly divergent.

Abdomen black. Hypopygium of the general structure of the ***nigripila*** group of the genus; pleurites stout, one pleural appendage much longer than the others, dusky in color, tapering gradually to the acute tip; the second appendage is shorter, flattened, subhyaline. The gonapophyses are flattened blades, deeply bifid apically with the proximal arm about twice the length of the outer arm.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 31, 1919 (R. Takahashi).

Paratopotypes, 1 ♂, March 26; 2 ♂'s, April 16, 1919.

Ormosia atripes sp. n.

Belongs to the ***nigripila*** group; general coloration black, including the legs; wings grayish brown; anal veins divergent.

Female—Length 5–5.3 mm.; wing, 5.8–5.9 mm.

Rostrum and palpi dark brownish black. Antennæ with the first scapal segment brown, second segment large, broadly pyriform, light yellow; flagellum dark brownish black, the segments oval (in the female sex). Head dark.

Sides of the pronotal scutellum yellowish white. Mesothorax blackish with a sparse dull yellowish brown pollen; scutellum with long coarse yellow bristles. Pleura black, a sparse group of from six to eight long erect yellowish hairs between the bases of the wings and halteres. Halteres light yellow. Legs with the coxæ brownish black; trochanters yellowish brown, brighter basally; femora dark brownish black, paler basally; remainder of the legs brownish black. Wings with a dark grayish brown suffusion, brighter basally and in the costal region; stigma indistinct, brown; a faint whitish spot beyond the stigma and a larger, somewhat more distinct, one at the fork of *M;* veins dark brown, *R* and *Cu* yellowish; wings broad with a dense delicate pubescence. Venation: *r* just beyond the fork of R_{2+3} on R_2; cell *1st* M_2 small, closed, the inner end narrowed, the outer deflection of M_3 a little longer than *m;* basal deflection of Cu_1 at or slightly before the fork of *M;* anal veins strongly divergent.

Abdomen black; tergal valves of the ovipositor strongly curved, black basally, dark horn yellow apically; sternal valves dark, the tips acute.

Habitat: Japan.

Holotype, ♀, Meguro, Tokio, April 10, 1919 (R. Takahashi).

Paratopotypes, 7 ♀'s, April 9–25, 1919.

Ormosia tokionis sp. n.

Belongs to the *fascipennis* group; general coloration gray; femora yellowish at the base; wings pale gray with a narrow pale brown seam along the cord.

Male—Length, about 3.8 mm.; wing, 5.2 mm.

Female—Length, about 4.5 mm.; wing, 6.1 mm.

Rostrum dark with a gray pollen. Palpi dark brown. Antennæ dark brown, short in both sexes, the flagellar segments oval in the male, clothed with a dense white pubescence. Head grayish brown, a little clearer brown along the margin of the eyes.

Mesonotal praescutum yellowish gray with four indistinct reddish brown stripes; tuberculate pits a little anterior to the level of the pseudosutural foveæ, separated from one another by a distance equal to, or a little less than. the diameter of one; scutellum and median area of the scutum lighter; postnotum gray. Pleura gray. Halteres rather long, dark brown, the base of the stem yellowish. Legs with the coxæ dark, covered with a yellowish gray pollen; trochanters dull brownish yellow; femora brown, the bases more yellowish, darker brown at the tips; tibiæ and tarsi brownish black. Wings pale gray, the veins narrowly and indistinctly seamed with brownish, more distinct along the cord; stigma large, brown; costal and subcostal cells a little more yellowish; veins dark brown. Venation: r on R_2, about its own length beyond the fork of R_{2+3}; deflection of R_{4+5} longer than $r\text{-}m$; cell *1st* M_2 closed; basal deflection of Cu_1 beyond the fork of M; anal veins divergent.

Abdomen dark brown. Male hypopygium small, the pleurites rather slender, nearly cylindrical; a single pleural appendage that is narrowed to the blunt, blackened apex, the surface with abundant setigerous punctures. Penis-guard a narrow, triangular chitinous plate, which has a narrow median apical point.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 23, 1919 (R. Takahashi).

Allotopotype, ♀, March 23, 1919.

Paratopotype, ♂, March 25, 1919.

Ormosia cinctifer sp. n.

Belongs to the *fascipennis* group; general coloration black, the body sparsely dusted with gray; wings nearly hyaline, a narrow brown seam along the cord.

Male—Length, 4.5–4.7 mm.; wing, 6.4–6.5 mm.

Female—Length, 5.6–5.8 mm.; wing, 6.3–7 mm.

Rostrum and palpi black. Antennæ black, short in both sexes, in the male the intermediate segments rounded oval, the apical segments long-oval. Head dark gray with a sparse brownish yellow pollen.

Mesonotal praescutum black, sparsely dusted with gray, with three blackish stripes, the median one shiny, the lateral stripes less distinct;

scutum similar, each lobe with a long-oval blackish area; scutellum and postnotum black, sparsely gray pruinose. Pleura black, gray pruinose. Halteres light yellow, the base of the stem dusky. Legs black. Wings nearly hyaline; stigma dark brown, conspicuous, sending a narrow brown seam along the cord; outer end of cell *1st* M_2 and vein *Cu* less distinctly seamed with brown; veins dark brown; the base of the wing more yellowish; wings with the pubescence rather short and sparse, almost lacking in the basal cells, including most of cell *M*. Venation: Sc_1 ending just beyond *r; r* on R_2 near its base; cell *1st* M_2 closed; *m* shorter than the deflection of M_3; basal deflection of Cu_1 slightly before the fork of *M; 2nd anal* vein slightly sinuous, but cell *1st A* broadest at the wing margin.

Abdomen black, including the male genitalia. Male hypopygium with the pleurites stout; pleural appendage oval, tumid, with long yellowish hairs, on the dorsal face with a chitinized plate, each side of which is heavily toothed, the outer margin with from five to six teeth and the inner margin with about three teeth; gonapophyses flattened, slender, tapering to the subacute tips. Ovipositor with the tergal valves horn color, darker basally.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 2, 1919 (R. Takahashi).

Allotopotype, ♀, April 2, 1919.

Paratopotypes, 2 ♂'s, 1 ♀, March 25–April 10, 1919.

Ormosia takahashii sp. n.

Belongs to the *varia* group; general coloration black, gray pruinose; wings grayish with the stigma brown; cell *1st* M_2 open; anal veins convergent; male hypopygium with eight chitinized points surrounding the penis-guard.

Male—Length, 3.8–4.2 mm.; wing, 5.4–5.5 mm.

Female—Length, 4.6 mm.; wing, 6.2 mm.

Rostrum and palpi dark brown. Antennæ brown, the flagellar segments long-oval, covered with a dense white pubescence, the flagellum with a single very long verticil before midlength of each segment to give the organ a secund appearance. Head dull gray.

Mesonotum dull brownish gray, the praescutum with indistinct, somewhat darker brown stripes, the interspaces with a row of coarse yellowish hairs; tuberculate pits very close together. Scutum dull gray, the lobes darker. Pleura black, sparsely gray pruinose; a few very long yellow hairs ventrad and caudad of the wing-base. Halteres yellow. Legs with the coxæ dark, sparsely gray pruinose; trochanters dull yellow; femora dark brown, the bases yellow; tibiæ and tarsi dark brown, clothed with a golden-yellow pubescence that is especially distinct in the female. Wings gray, the stigma darker brown, lying beyond *r;* veins dark brown, the base of the wing slightly brighter. Venation: Cell *1st* M_2 open by the atrophy of the outer deflection of M_3; basal

deflection of Cu_1 just before the fork of *M; 2nd anal* vein sinuous, at its tip bent rather strongly toward the first anal.

Abdomen dark brownish black. Male hypopygium with the pleurites rather stout, covered with sparse prominent tubercles that bear coarse yellow setæ, which are longest at the tips of the pleurites; pleural appendages two, the outer appendage fleshy, the outer face with an abundant short brownish, appressed pubescence, arranged in transverse rows; inner appendage narrowed and chitinized at the tip, the inner face with about nine or ten stout setæ. Penis-guard terminating in two subparallel slender black spines; two pairs of gonapophyses, the inner pair simple and ending in an acute blackened point; outer gonapophyses bifid, the lateral arm much longer and more slender than the proximal arm. Eighth sternite with a short, flattened, subspatulate median lobe.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 2, 1919 (R. Takahashi).

Allotopotype, ♀, April 7, 1919.

Paratopotypes, 19 ♂ ♀, March 25–April 25, 1919; paratype, ♀, May 29, 1919; 6 ♂ ♀, October 2–21, 1919.

The autumnal specimens are much smaller than the vernal material, but show no other differences.

It is with great pleasure that this interesting fly is dedicated to its discoverer, Mr. Ryoichi Takahashi.

Erioptera Meigen.

Erioptera bifurcata sp. n.

General coloration gray, the mesonotum with three brown stripes; legs black with whitish scale-like hairs; wings yellowish, vein *Sc* yellow; cell *1st* M_2 open; anal veins divergent.

Male—Length, 5–5.5 mm.; wing, 6.1–7.1 mm.

Rostrum black, densely gray pruinose; palpi dark brown. Antennæ black, the segments oval, covered with a dense white pubescence, the verticils short, barely projecting beyond the pubescence. Head broad, light gray, the eyes widely separated above, the ventro-caudal angles almost contiguous beneath.

Pronotum light gray. Mesonotal praescutum gray with three brown stripes, the median stripe broad, slightly constricted by the conspicuous, elongate pseudosutural foveæ, indistinctly bisected by a pale median line; tuberculate pits small, very widely separated, lying slightly anterior to the level of the pseudosutural foveæ; scutum gray, the lobes indistinctly marked with brown; remainder of the mesonotum gray. Pleura clear light gray. Halteres light yellow, the extreme base dark. Legs with the coxæ and trochanters black, gray pruinose; remainder of the legs black, densely covered with flattened whitish, scale-like hairs. Wings with a faint yellow tinge, the base of the wing

more yellowish; stigma very narrow and indistinct, brown, confined to vein R_1; veins dark brown, Sc yellow. Venation: Sc long, ending opposite r; r on R_2 about its own length beyond the fork of R_{2+3}; cell *1st* M_2 open by the atrophy of m; basal deflection of Cu_1 beyond the fork of M; anal veins divergent.

Abdominal tergites gray, the sixth and seventh segments with a transverse median brown blotch; the basal segments on either side with blackish impressed rectangular areas; pleural appendages of the hypopygium yellowish with the tips blackened. Male hypopygium with the ninth tergite deeply notched medially; pleurites rather slender, at the apex with two pleural appendages; dorsal appendage long, slender, the tips blackened; ventral pleural appendage short, deeply bifid, the cephalic or proximal arm more slender, at its tip with a single long bristle; the caudal or lateral arm broader, its flattened apex densely set with roughened tubercles. Gonapophyses very long, almost straight, tapering to the acute tips.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 4, 1919 (R. Takahashi).
Paratopotypes, 4 ♂'s, April 4–9, 1919.

Limnophila Macquart.

Limnophila (Lasiomastix) **pilifer** sp. n.

Antennæ short in both sexes; wings yellowish at the base, the apical cells strongly pubescent.

Male—Length 6–7 mm.; wing, 8.6–8.7 mm.

Female—Length, 8.5–9.5 mm.; wing, 8.8 mm.

Rostrum and palpi dark brownish black. Antennæ short in both sexes; first scapal segment reddish brown, sparsely gray pruinose, second segment reddish; basal segments of the flagellum brown, paler basally, apical flagellar segments more elongate, dark brown; flagellar segments clothed with a pale pubescence. Head gray.

Pronotum large, dark colored, light gray pruinose. Mesonotum shiny jet black with an easily removed, but dense pollen, brownish yellow on the median area of the praescutum, clearer gray on the remainder of the thorax, including the pleura. Halteres light yellow. Legs with the fore coxæ black, grayish pruinose; middle coxæ dull brownish yellow, dark at the extreme base; hind coxæ largely brownish yellow; trochanters dull yellow; femora yellow, the tips broadly dark brown; tibiæ yellowish brown, the tips darkened; tarsi dark brownish black, the base of the metatarsi brown. Wings grayish, strongly yellow at the base, this color including most of the costal and subcostal cells; stigma oval, grayish brown, almost evenly split by r; narrow gray seams along the cord, outer end of cell *1st* M_2, origin of Rs, and the forks of R_{2+3} and M_{1+2}; veins brown, those in the costal and basal regions yellowish; apical cells of the wings strongly pubescent, this extending from cell *2nd* R_1 to cell Cu_1. Venation: Sc_2 slightly removed from the

tip of Sc_1; Rs long, in alignment with R_{2+3}, this latter shorter than the basal deflection of Cu_1; r removed from the tip of R_1; inner ends of cells R_3, R_5, and *1st* M_2 in oblique alignment; petiole of cell M_1 about equal to or shorter than this cell; basal deflection of Cu_1 slightly before mid-length of cell *1st* M_2. Some of the specimens in this series show abnormal types of venation.

Abdomen dark brownish black, the hypopygium a little reddish. Male hypopygium with the outer appendage almost straight, split into two short points at the apex; the inner appendage deeply bifid, the outer arm flattened, subspatulate, the blade setigerous, the inner arm much smaller and narrowed to the blunt apex; gonapophyses slender, acicular, much twisted. Valves of the ovipositor rusty horn color, very long and slender, the tergal valves almost straight, slightly upcurved at the tips.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 8, 1919 (R. Takahashi).
Allotopotype, ♀, April 19, 1919.
Paratopotypes, 18 ♂ ♀, April 7–25, 1919.

Limnophila (Ephelia) **subaprilina** sp. n.

Mesonotal praescutum yellowish gray, the lateral brown stripes connected with the intermediate pair by a subtransverse brown line; wings with a heavy brown pattern; abdominal segments bicolorous.

Male—Length, 5.6 mm.; wing, 7.3–7.4 mm.

Female—Length, 8.7 mm.; wing, 8.4 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown, the basal flagellar segments pale brown, the apical segments darker. Head brownish gray, more yellowish along the inner margin of the eyes and on the front.

Mesonotal praescutum yellowish gray with broken dark brown stripes; the intermediate stripes are separated from one another by a distance that is nearly equal to the width of one, indistinct in front, not reaching the suture behind; lateral stripes short, their cephalic ends with a transverse bar to form a T-shaped mark that connects more or less completely with the intermediate stripes and with the lateral margin of the praescutum; scutum yellowish gray; scutellum and postnotum clearer gray. Pleura yellowish gray with conspicuous dark brown blotches. Halteres yellow, the knobs dark brown. Legs with the coxæ dark brown; trochanters brown, with a black spot on the posterior face; femora dull yellow, the tips broadly dark brown; tibiæ brownish yellow, the tips narrowly and indistinctly darkened; tarsi dark brown, the first and second segment yellowish brown with only the tips darkened. Wings grayish subhyaline, the costal and subcostal cells more yellowish; a heavy dark brown pattern along the costal margin and large grayish brown blotches on the cross veins, deflections of veins, and along the margin at the ends of the longitudinal veins; there are seven costal blotches, the basal one broken, subocellate; the

third at the origin of *Rs* extending from costa almost to *M;* the fifth, largest, at the stigma; the last two at the ends of R_1 and R_2 respectively; a narrow cloud in the anal angle of the wing; the seam along the supernumerary cross vein sends a very black line along vein *Cu* to form an inverted T; veins *C* and *Sc* yellow, the other veins brown. Venation: *Rs* strongly arcuated at origin; R_{2+3} and M_{1+2} nearly equal in length.

Abdominal segments bicolorous, the basal half of each segment dull reddish, the apical half blackish. Male hypopygium with the outer pleural appendage stout, on the outer face before the tip with one conspicuous spine in addition to the apical, slightly curved, tooth.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 20, 1919 (R. Takahashi).

Allotopotype, ♀, April 19, 1919.

Paratopotype, ♂, April 19, 1919; paratype, ♂, Tokio, May, 1919.

Limnophila (Prionolabis) **rufipennis** sp. n.

General coloration blackish, femora a little paler basally; wings brownish yellow with sparse brown seams along the cord; cell *1st* M_2 subquadrate, basal deflection of Cu_1 beyond the middle of its length.

Male—Length about 14 mm.; wing, 16.4 mm., its greatest width, 5.5 mm.

Description from an alcoholic specimen.

Rostrum, palpi and antennæ black. Head black, very possibly grayish pruinose in dried specimens.

Thorax black throughout in alcoholic material. Halteres long, light yellow, the knobs a little darker. Legs with the coxæ black; trochanters dark brown; femora dark brown, only a little paler basally, especially on the hind femora; tibiæ and tarsi dark brownish black. Wings very broad and ample, deeply suffused with pale brownish yellow, clearer yellow in the costal and subcostal cells; stigma oval, dusky brown; very narrow dusky brown seams along the cord, at the outer end of cell *1st* M_2, at the origin of *Rs* and at the fork of M_{1+2}. Venation generally similar to *L.* (*P.*) *rufibasis* O. S. (Northeastern North America), but cell *1st* M_2 much shorter, subquadrate; R_{2+3} a little longer than *r-m;* basal deflection of Cu_1 beyond mid-length of cell *1st* M_2; petiole of cell M_1 a little shorter than this cell.

Abdomen dark brownish black. Male hypopygium with the ventral pleural appendage irregularly pectinated, one tooth being considerably larger than the others; dorsal pleural appendage with the apex simple, blackened.

Habitat: Japan.

Holotype, ♂, Chichibu, Province Saitama, October, 1918, (R. Takahashi).

Polyangæus Doane.

Polyangæus japonicus sp. n.

Thorax yellow, the praescutum with an indistinct darker median stripe; wings with a heavy brown banded pattern; crossvein ***r*** lacking, ***m*** present; supernumerary crossveins in cells R_3, R_5, M_1 and *M;* tibiæ and tarsi largely white.

Male—Length, 6.6 mm.; wing, 8 mm.

Head small, closely applied to the thorax. Rostrum and palpi dark brown. Antennæ short, the flagellar segments crowded, the scape dark brown, the flagellum light brownish yellow, the last segment infuscated. Head dark brownish gray.

Mesonotum light yellow, the praescutum with a broad pale brown median stripe that is broadest and most distinct in front, becoming obliterated behind; postnotum brownish. Pleura yellow. Halteres very long and slender, dark brown, the base of the stem yellow. Legs with the coxæ and trochanters dull yellow; femora dull yellow, the tips broadly dark brown; tibiæ china-white, the tips broadly dark brown; tarsi white, the apical segments more infuscated. Wings subhyaline with a heavy banded pattern of dull yellowish, margined with brownish gray; the costal cell is entirely dark; interrupted crossbands occur at the origin of the sector, along the cord and very diffusely between the cord and the wing-tip; dark spots at the ends of all the longitudinal veins, large and blotch-like at the ends of the anal veins; a row of small dots in cell *Cu*, behind the abortive anal vein in that cell; two spots in the base of cell *1st A;* the apical pattern consists of yellowish seams to the crossveins, these markings broadly margined with brownish gray to produce a somewhat ocellate appearance. Venation: *Rs* square and spurred at its origin; ***r*** lacking but a strong spur at the angle of R_{2+3} at the point where ***r*** is located in the genotype, *P. maculatus;* R_{2+3+4} longer than ***r–m;*** cell *1st* M_2 closed, ***m*** being located between M_2 and M_3; supernumerary crossveins in cells R_3 near the tip, R_5 at about two-thirds its length, at about midlength of M_1 and in cell *M* about in alignment with the angulated base of the sector.

Abdomen brown, the segments margined posteriorly with darker brown.

Habitat: Japan.

Holotype, ♂, Saitama, May 31, 1919 (R. Takahashi).

Polyangaeus japonicus agrees with the genotype, *P. maculatus* Doane (Western United States) in most features of its organization. It differs in the lack of the radial crossvein, the closed cell *1st* M_2 and the presence of an additional supernumerary crossvein in cell M_1.

Rhaphidolabis Osten Sacken.

Rhaphidolabis flavibasis sp. n.

Antennæ with fourteen segments, the last segment enlarged; mesonotal praescutum light gray, with three dark brown stripes; base of the wings strongly yellowish; male hypopygium with the outer angle not produced into a lobe, the appendages borne at the narrow apex.

Male—Length, 7 mm.; wing, 8.7–8.9 mm.

Female—Length, 7.5–8 mm.; wing, 9.4–9.8 mm.

Rostrum and palpi dark brown. Antennæ dark brownish black, the first scapal segment gray pruinose, the second scapal segment a little brighter apically; there are twelve flagellar segments which gradually decrease in size to the end of the terminal, one much larger than the penultimate and seemingly produced by the union of two small segments. Head light brownish gray, clearest along the inner margin of the eye; an indistinct dark median line; vertical tubercle low.

The mesonotal praescutum light gray with three dark brown stripes, the intermediate stripe entire; remainder of the mesonotum plumbeous, gray pruinose. Pleura light gray. Halteres dark brown, the basal third of the stem bright yellow. Legs with the coxæ gray; trochanters brown; femora dark brown, brighter on the basal third; tibiæ and tarsi dark brownish black. Wings grayish subhyaline, the costal and subcostal cells a little more yellowish; base of the wings bright yellow, including the veins; stigma distinct, brown; veins dark brown. Venation: *Rs* short, slightly arcuated to feebly angulate near midlength; R_2 ublique, its fusion with R_1 at the wing tip slight; R_{2+3+4} rather short, osually a little longer than *r-m;* cell M_1 present; cell *1st* M_2 open.

Abdomen dark brown, sparsely gray pruinose. Male hypopygium with the pleurites short and stout, at the apex with the two small pleural appendages, an outer subcircular fleshy lobe whose inner face is densely set with short black spinous setæ; inner pleural appendage more chitinized, slightly curved, along the inner margin with about a dozen spinous setæ that are stouter and more crowded near the tip; lateral gonapophyses slender, bent at a right angle near midlength. Ovipositor rusty in color.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 27, 1919 (R. Takahashi).

Allotopotype, ♀, April 4, 1919.

Paratopotypes, 8 ♂ ♀, March 20–April 9, 1919.

One teneral female that may represent still another undescribed species has cell R_3 sessile, the petiole being entirely lacking. The praescutal stripes are less distinct than in the specimens above described.

Dicranota Zetterstedt.

Dicranota nipponica sp. n.

Antennæ with twelve segments, the terminal segment small; mesonotal praescutum grayish buff, with three dark brown stripes, the median one of which is split by a capillary line of the ground color; male hypopygium at the outer angle produced caudad into a lobe.

Male—Length, 7.5 mm.; wing, 8.7 mm.

Rostrum and palpi brown. Antennæ dark brownish black, the flagellar segments with a conspicuous erect white pubescence in addition to the verticils; but ten flagellar segments are evident, the last much smaller than the penultimate; first flagellar segment long clavate, much longer than those following. Head brownish gray, very narrowly clearer gray along the inner margins of the eyes.

Thorax light grayish buff, the praescutum with three dark brown stripes of which the intermediate one is distinctly split by a capillary vitta of the ground color; scutal lobes gray marked with pale brown; scutellum, postnotum and pleura light gray. Halteres pale brown, brighter at the base. Legs with the coxæ light gray, more yellowish apically; trochanters dull yellow, the outer margins blackened; femora brownish yellow, brighter at the base, the tips dark brown; tibiæ dark brown, the tips black; tarsi dark brownish black. Wings with a pale gray tinge; stigma elongate, brown, extending from *r* to the tip of R_{1+2}; veins dark brownish black, the veins at the wing base a little paler. Venation: *Rs* very short, strongly angulated to almost square at its origin, slightly spurred; R_{2+3+4} short, about equal to *r-m;* apical fusion of R_2 with R_1 slight; cell *1st* M_2 open, cell M_1 present.

Abdomen dark brownish gray, the tergites very narrowly margined caudally with paler gray; sternites similarly margined with yellowish gray and with an indistinct broken median yellowish stripe. Male hypopygium with the outer angle of the pleurites extended caudad into a blunt hairy lobe; two pleural appendages, the inner one of which is curved, flattened and expanded distally, not conspicuously armed with setæ and spines.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 30, 1919 (R. Takahashi).

Cylindrotoma Meigen.

Cylindrotoma japonica sp. n.

Antennæ rather short, dark brownish black; front and a broad margin around the eyes yellow; praescutal stripes entirely confluent, the interspaces with a deep grooved impression.

Male—Length about 13–14 mm.; wing, 10.8–11.5 mm.

Female—Length, 13.5 mm.; wing, 13 mm.

Rostrum and palpi dark brown. Antennæ rather short for this genus of flies, dark brownish black, the flagellar segments with the posterior face straight, the anterior or inner face gently convex. Front and a broad margin around the eyes yellow, remainder of the head shiny black, microscopically punctured.

Pronotal scutum dark, the scutellum yellow, darker medially. Mesonotal praescutum with the disk black, subopaque, with deep, impressed longitudinal grooves in the usual interspaces; scutal lobes and the posterior half of the postnotum black, remainder of the mesonotum yellow. Pleura pale whitish yellow, the sternopleura and mesopleura, as well as an oval spot cephalad of the base of the halteres shiny black. Halteres pale yellow, the knobs scarcely darker. Legs with the coxæ light brown, the outer face marked with darker brown; trochanters dull yellow; femora yellow, the tips broadly black; tibiæ brownish yellow, tipped with black; tarsi black, the base of the metatarsi a little paler. Wings broad, grayish yellow, the basal and costal areas brighter; stigma dark brown, oval; veins dark brown. Venation: cell *1st* M_2 not greatly elongated; cell M_1 short-petiolate.

Abdominal tergites reddish brown, the segments margined laterally and caudally with black; in some specimens these markings completely cover the dorsum; sternites reddish, indistinctly margined laterally and caudally with dark brown; male hypopygium greatly enlarged, black; ovipositor black.

Habitat: Japan.
Holotype, ♂, Saitama, May 29, 1919 (R. Takahashi).
Allotopotype, ♀, May 31, 1919.
Paratopotypes, 2 ♂s.

Liogma Osten Sacken.

Liogma serraticornis sp. n.

General coloration deep shiny black; flagellar segments in the male deeply serrated; wings with the stigma yellow or brownish yellow.

Male—Length about 15 mm.; wing, 12–12.1 mm.

Female—Length about 14 mm.; wing, 12 mm.

Rostrum dark brown; palpi yellowish brown. Antennæ with the scape brownish yellow, the flagellum dark brownish black, the flagellar serrations in the male sex very long, considerably more so than in *L. kuwanai;* there are seventeen segments, the last two of which are slender and not serrate. Head shiny black.

Thoracic dorsum shiny black, the postnotum sculptured. Pleura shiny black, the dorso-pleural membranes pale. Halteres yellow. Legs with the coxæ largely black on their outer faces; trochanters dull yellow; femora pale yellow, the tips broadly black; tibiæ yellowish brown, the tips blackened; tarsi black. Wings with a strong yellowish gray tinge, the costal region, the stigma and the space between *Cu* and the abortive anal vein behind it yellowish; veins dark brown, excepting

Sc and *R*, which are yellowish. Venation: ***r-m*** sometimes present, but short, at other times obliterated by the punctiform contact or short fusion of R_{4+5} on M_{1+2}; basal deflection of Cu_1 before or slightly beyond the fork of *M*.

Abdomen shiny black throughout.

In the female sex, the antennæ are much shorter and less distinctly serrated; only the second scapal segment is pale; the stigma and costal region of the wing brownish yellow; the valves of the ovipositor short and flattened, black, their tips rusty brown.

Habitat: Japan.

Holotype, ♂, Saitama, May 30, 1919 (R. Takahashi).

Allotopotype, ♀, May 29, 1919.

Paratopotypes, 2 ♂'s, 2 ♀'s, May 29, 1919.

Liogma kuwanai is a gray fly with the stigma dark brown and the femora brown with only the bases yellow.

Phalacrocera Schiner.

Phalacrocera mikado sp. n.

Antennæ simple; mesonotum shiny black, the lateral margins of the praescutum, the scutellum and the anterior half of the postnotum pale; abdomen shiny black.

Male—Length about 11 mm.; wing, 12.2 mm.

Female—Length about 12 mm.; wing, 11.5–11.8 mm.

Rostrum and palpi dark brown. Antennæ with sixteen segments, simple in both sexes; in the male elongate-cylindrical, clothed with an abundant white pubescence; antennæ dark brown, the bases of the first two flagellar segments more yellowish. Head with the vertex between the eyes pale brown, the remainder shiny brownish black. Head strongly narrowed behind.

Mesonotal praescutum shiny black, the lateral margins and the humeral regions pale; scutal lobes black; remainder of the dorsum pale except the posterior portion of the postnotum, which is darkened. Pleura pale, the mesopleura and sternopleura shiny black. Halteres pale brown, the base of the stem paler. Legs with the coxæ pale, the outer faces more or less darkened, especially on the mesocoxæ; trochanters pale; femora pale, the tips dark brown; tibiæ pale brownish white, the tips dark; tarsi dark brown. Wings pale grayish, the stigma oval, pale yellowish brown; veins brown. Venation: ***m*** and ***r-m*** present, long; in the allotype the tip of vein R_2 is indistinctly persistent in both wings, but in the other specimens there is no trace of this vein.

Abdomen shiny black; hypopygium small.

Habitat: Japan.

Holotype, ♂, Tokio, April, 1919, (R. Takahashi).

Allotopotype, ♀.

Paratype, ♀, Saitama, May 29, 1919, (R. Takahashi).

Nesopeza Alexander

Nesopeza tarsalis sp. n.

Mesonotal praescutum with the stripes shiny brown, confluent; legs black, the tips of the tarsi white; wings with the stigma dark brown, with a pale area before and beyond it.

Male—Length about 10 mm.; wing, 12 mm.

Female—Length about 13 mm.; wing, 12.3 mm.

Frontal prolongation of the head and the palpi dark brown. Antennæ of the male moderately elongated, if bent backward extending about to the base of the abdomen, the scape yellow, the flagellum dark brown. Head yellowish, passing into dark brown on the posterior portions of the vertex.

Mesonotal praescutum shiny brown, the stripes confluent, the humeral angles yellowish; scutal lobes dark; remainder of the mesonotum paler. Pleura yellowish with a shiny black streak or band extending from the sternum across the mesopleura to the praescutum; a black spot between the middle and hind legs. Halteres dark brown, the base of the stem paler. Legs with the coxæ and trochanters yellow; femora dark brown, paler at the base; tibiæ and tarsi dark brownish black, the tips of the latter pure white, these about equal in width on all the legs or a trifle broader on the hind legs where about the apical half is pale. Wings gray, the stigma dark brown; a whitish subhyaline area before and beyond the stigma; a narrow seam on the basal deflection of R_{4+5} and the tip of the wing faintly infuscated. Venation: *Rs* not so elongate as in *N. geniculata* and the medial forks deeper.

Abdomen shiny dark brown, the basal sternites and the sides of the second and third tergites more yellowish; hypopygium brownish black. In the female the abdominal tergites are uniformly dark.

In the living specimens the body is probably with decided greenish tints as traces of these persist in the pinned individuals.

Habitat: Japan.
Holotype, ♂, Saitama, May 29, 1919 (R. Takahashi).
Allotopotype, ♀.
Paratopotype, ♀.

Tipula Linnæus.

Tipula joana sp. n.

Antennæ black, the scape orange-yellow; praescutum gray with three darker gray stripes, the median stripe split by a capillary black line; wings strongly petiolate, a seam along the cord and the apex brownish black; *2nd Anal* cell very narrow.

Male—Length, 18–20 mm.; wing, 17–18 mm. Fore leg, femur, 11 mm.; tibia, 13.6 mm.; hind leg, 13 mm.; tibia, 15.8 mm.

Frontal prolongation of the head reddish brown, the dorsal surface light gray pruinose; nasus distinct. Palpi pale brown, the last segment,

with the exception of the base, light yellow. Antennal scape orange-yellow, the flagellum black, the segments of the latter nearly cylindrical, with a dense, microscopic white pubescence. Head light gray, the sides of the vertex more brownish, set with abundant setæ.

Mesonotal praescutum light gray, with three darker gray stripes, the median stripe broadest, strongly narrowed behind, split by a capillary velvety-black line; scutum light gray, each lobe with two darker gray blotches; scutellum and postnotum darker gray. Pleura dark colored, with a dense blue-gray pollen, the dorso-pleural membrane conspicuously dull yellow. Halteres brown, the extreme base brownish yellow. Legs with the coxæ blue-gray; trochanters yellow; femora brownish-yellow, brightest at the base, the tips brownish black; tibiæ brownish black, darkest apically, the posterior tibiæ with a broad, indistinct, whitish, sub-basal band; tarsi black. Wings with a faint yellowish tinge, brightest at the wing-base; costal cell more saturated; subcostal cell dark; stigma dark brownish black; a broad dark brownish black seam along the cord; wing-apex blackish, this occupying the end of cell R_2, nearly the apical half of cells R_3 and R_5 and part of M_1. Venation: *Rs* short; R_2 persistent; *2nd Anal* vein running very close to the anal margin so the *2nd Anal* cell is very narrow. The wing is strongly petiolate.

Abdomen with the basal tergites yellowish, especially laterally, the fifth to ninth tergites black; sternites paler; abdominal segments margined laterally and ringed caudally with paler. Male hypopygium not conspicuous; ninth tergite rather small, the caudal margin almost straight across or but feebly notched. Outer pleural appendage rather small, flattened, greenish white in color, broadest at the base, tapering gradually to the apex. Inner pleural appendage pale greenish, terminating in two subequal blackened spines that are slightly divergent, claw-like; a broadly spatulate blade projects toward the ninth tergite. Ninth sternite with a small but deep V-shaped median notch. Eighth sternite projecting caudally, the margin unarmed.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 23, 1919 (R. Takahashi).

Paratopotype, ♂.

This exquisite species is dedicated to the memory of my mother, Mrs. Jane Parker Alexander. It shows numerous points of resemblance to *T. pedata* Wied. and allied forms and if the group *Tipulodina* Enderlein is to be recognized as a valid genus this species will probably have to be placed therein, although the hypopygium is strikingly different from that of the genotype of *Tipulodina* (*pedata*). For a discussion of the status of the group *Tipulodina*, consult a paper by the writer, Proceedings of the United States National Museum, vol. 49, p. 184; 1915.

WING STRUCTURE OF LEPIDOPTERA AND THE PHYLOGENETIC AND TAXONOMIC VALUE OF CERTAIN PERSISTENT TRICHOPTEROUS CHARACTERS.

By ANNETTE F. BRAUN, Cincinnati, O.

I. INTRODUCTION.

It is agreed that the insects constituting the two orders Trichoptera and Lepidoptera respectively are closely related genetically. All insects included in these orders have the same general and characteristic type of venation, which in the more primitive forms closely approaches the hypothetical primitive type as figured by Comstock. It is the problem of determining where the line of division shall be drawn between Lepidoptera and Trichoptera which presents difficulties. According to the usually accepted classification, the Micropterygidæ are regarded as the most primitive group of Lepidoptera, from which all the other Lepidoptera have been derived. This group more closely resembles in venation and mode of uniting the fore and hind wing in flight the more generalized of the Trichoptera than it does any other group of insects, evidently approaching the stem form from which both groups have been derived. On the basis of certain common and characteristic features in venation, and the identical structure of the fibula in both, Comstock ('18) removes the Micropterygidæ from the Lepidoptera, confirming his conclusion by the results of Dr. T. A. Chapman's studies of pupæ, and makes them one suborder of the Trichoptera, the Micropterygina, the members of Trichoptera as usually recognized constituting the other suborder, the Phryganeina.

In addition to the Micropterygidæ, there is another group of moths, the Nepticulidæ, the more generalized members of which possess a fibula identical in structure with that of the

Micropterygidæ and the generalized Trichoptera,* and a pupa resembling that of the Microptergyidæ. The venation of the Nepticulidæ (Braun, '17) shows highly specialized features. It resembles most closely the venation of some of the Hydroptilidæ, but shows extreme anastomosis of main veins and absence of cross-veins. It differs from that of Hydroptilidæ chiefly in the few points in which the Nepticulidæ approach the usual type of venation in the frenate Microlepidoptera with reduced venation. The existence of this group, which shows undoubted trichopterous affinities, further complicates the question of the true relationship existing between the Trichoptera, the Micropterygidæ, the Nepticulidæ, the Hepialidæ, and the frenate Lepidoptera.

The discovery of another family, the Prototheoridæ (Meyrick, Annals South African Museum, XVII, 17, 1917), with characters intermediate between the Micropterygidæ and the Hepialidæ, would seem to make it impossible to place the Micropterygidæ and Hepialidæ in different orders.

In two related groups, any adaptation for a particular function may have been handed down from the common ancestor of the two, or it may be a similar modification of an homologous structure arising independently in each group, because of the same inherent tendencies in each, or the adaptations serving the same purpose may be developments of entirely different structures in the two groups. The two former conditions indicate community of descent and closeness of relationship; the third the phylogenetic divergence of the two groups. The same principles may be applied in the analysis of the entire structure of the groups whose true relationship is to be determined. If it can be shown, that the more primitive members of one group having many characteristics in common with the primitive members of another group and thus appearing more closely related to them than to any other group, show the beginning of divergence in structure from that other group, and these modifications can be consistently traced in the same direction through the more specialized members of the first group, in my opinion the point where the two groups begin to diverge, that is, the point where the distinctive characteristics of a group originate, is the logical place to make a taxonomic

* The term Trichoptera is used in this paper in its commonly accepted sense, not including the Micropterygidae.

division, even though an apparently wider gap may exist somewhere between two divisions of a group, due to incomplete preservation of connecting forms or insufficient knowledge on our part.

In the present paper, the relative value of those factors indicating community of descent and relationship of the insects constituting the Trichoptera and Lepidoptera and those indicating divergence is considered in its bearing on the question of classification.

With regard to the taxonomic problem involved, the question is essentially this: Are certain characteristics possessed by the Micropterygidæ in common with the Trichoptera of such taxonomic importance as to necessitate the conclusion that the Micropterygidæ are trichopterous insects or are these characteristics merely retained as a common inheritance, later to undergo far-reaching modifications which can be traced back to the Micropterygidæ.

Certain characters which are possessed in common by the Micropterygidæ and Trichoptera and which seem sharply to separate the Micropterygidæ from frenate Lepidoptera, will be shown to undergo far-reaching modification and in this modified form to persist in many of the comparatively primitive groups of the frenate Lepidoptera. The fact that the course of such modification can be traced makes it evident that the gap between the Micropterygidæ and the remaining Lepidoptera is not as wide as is sometimes supposed. This fact, and the fact that certain acknowledged lepidopterous characters originate in the Micropterygidæ, necessitate the conclusion that the Micropterygidæ are lepidopterous insects.

II. Wing Structure.

The structure of the wings presents the most obvious and available characters for the study of the phylogeny and taxonomy of the Lepidoptera and Trichoptera. The following discussion of the structure of wings of Lepidoptera deals with the modification and disappearance of trichopterous characters and with the origin of some distinctively lepidopterous characters. The data are presented under (a) venation, (b) mode of insuring synchronous action of fore and hind wings, (c) distribution of fixed hairs.

(*a*) *Venation.*

Certain striking characteristics of venation are held in common by the more generalized Trichoptera, such as *Rhyacophila* and by the more generalized of the Micropterygidæ. These characteristics have been enumerated by Comstock (The Wings of Insects, 1918, p. 317). In fact, the resemblance is so close that the only essential difference to be noted is that in Micropterygidæ media of both wings has been reduced to a three-branched condition, apparently by the coalescence of M_3 and M_4, while in *Rhyacophila* M_3 and M_4 are separate in the fore wing, although united in the hind wing. This identity of characteristics is shared by no insect not belonging to Micropterygidæ or Trichoptera. That it is possible to trace the modification of these trichopterous characters and their transformation into what are commonly recognized as the usual lepidopterous characters, such as are found in the frenate Lepidoptera, will be shown from evidence derived from the Micropterygidæ themselves, the Nepticulidæ, the more primitive frenate Lepidoptera, and the Hepialidæ.

The forms for study of venation in the more primitive Lepidoptera have been chosen because they show, besides the preservation of media, certain characters—such as the costal spines on the hind wing, absence of frenulum in the female, fixed hairs on the wings and folded maxillary palpi—all of which indicate a generalized condition.

In the Micropterygidæ veins *Cu* and *1st A* of both fore and hind wing coalesce at the base of the wing; from their point of separation *Cu* extends obliquely across the wing toward media, then bends and extends longitudinally to the margin. In the hind wing, the point of separation of *Cu* and *1st A* is nearer the base than in the fore wing. A short cross-vein, the posterior arculus, connects media with the longitudinal part of *Cu*, forming with the base of media, a serial vein in the fore wing. The presence of this condition in *Mnemonica* and in *Rhyacophila* is pointed out by Comstock in his book "The Wings of Insects," where wings of both are figured together with figures of the tracheation in the base of the wings of *Mnemonica*, which confirm the homologies of the veins as determined from a study of adults. In so far as published figures of other genera of the Micropterygidæ show the details

of venation at the base of the wings, they indicate that these conditions are common to all members of the family, although not without modification which may tend to obscure these characters. That such modification does take place in the Micropterygidæ, is shown by an examination of the wings of *Epimartyria* (Fig. 1), which genus, since it precedes the appearance of the tongue, must be regarded as a more primitive genus than *Mnemonica*. In the fore wing, the configuration of these veins is essentially that of *Mnemonica*. In the hind wing, *Cu* extends straight to the margin from its point of separation from the *1st A*, that is, the "oblique" part of *Cu* has become so extremely oblique as to be in a line with the longitudinal part of *Cu*. As is to be shown presently, this differs in no way from the course of *Cu* of the hind wing in certain undisputed Lepidoptera. In *Prodoxus*, most of the tracheae are preserved in the extreme base of the wings. Figure 2 shows the more general features of the venation, with wavy lines representing tracheæ; Figure 3 shows in detail the course of the tracheæ at the extreme base of the hind wing. In the fore wing the coalesced bases of *Cu* and *1st A* contain a single trachea, which soon divides, one branch following the *1st A*, the other branch immediately dividing again, both branches traversing *Cu*, but soon shriveling up. That portion of *Cu* between its separation from *1st A* and the posterior arculus (which is here transverse and contains no trachea) is evidently homologous with the oblique free portion of *Cu* in Micropterygidæ and Trichoptera. The tracheæ in the base of the hind wing (Fig. 3) show that the relations of *Cu* to the *1st A* are apparently the same as in the fore wing, but the separation takes place extremely close to the base, and the course of the veins is obscured by the tuberosities at the base of the wing. It will be observed that the vein containing a branched trachea, evidently the cubital trachea, is met very obliquely near the base of the wing by a vestige of what appears to be the posterior arculus. The evidence afforded by a study of pupal wings of *Prodoxus* (Fig. 6) supports the conclusions derived from a study of adult wings. The coalescence of *Cu* and *1st A*, the Z-shaped course of *Cu*, and the formation of the serial vein are sometimes shown with greater distinctness in the fore wing of *Adela bella* (Fig. 5), where these features of the venation are almost exactly as in *Mnemonica;* a similar condition is present

in the hind wing. The course of these veins is also the same in *Cyanauges cyanella*, as reference to Figure 4 will show; in this case the separation of *Cu* and *1st A* occurs almost at the base of the wing.

The obvious conclusion to be drawn from this series of examples is that in the course of evolution, the point of separation of *Cu* and *1st A* moves toward the base of the wing, and concomitant with this change, the oblique basal part of *Cu* becomes more and more oblique until by the time the point of separation has reached the base of the wing, the formerly oblique free basal part of *Cu* is in a line with the longitudinal part of *Cu*. There will thus be no evidence in the venation of this part of the wing in the more specialized Lepidoptera to indicate that it is derived from a venation like that of *Mnemonica*. What appears to be the posterior arculus is usually obsolescent (as indicated in the Figures by dotted lines), but vestiges of it sometimes traversed by a persistent trachea are present in many Lepidoptera belonging to widely separated groups, e. g., in Tineidæ (e. g., *Tineola*), Plutellidæ (e. g., *Pliniaca*), Eucleidæ (e. g., *Sisyrosea textula*), Tortricidæ, and possibly in other groups. The question whether this is really the posterior arculus or the base of M_4 is not discussed here. In the light of what has been shown to have taken place in more primitive forms, the configuration of veins in the base of the fore wing of the Noctuid, *Renia flavipunctalis* (Fig. 7), suggests the same course of evolution. The coalescence of the base of the first anal trachea with the cubital trachea, shown in the pupæ of some butterflies, and in some of the specialized moths (e. g., *Samia cecropia*), I am inclined to regard as a secondary connection, following the separation of *Cu* and *1st A* at the base.

The venation of the fore wing of the more generalized members of the Nepticulidæ is characterized by the basal coalescence of media and cubitus, a character unique in Lepidoptera, but whose origin can be explained by assuming that processes similar to what is known to occur in some Trichoptera have taken place. The cubital and medial tracheæ lie within the same vein cavity near the base (Fig. 8), the two separating at the point where media bends forward to join radius. This characteristic of the venation of the Nepticulidæ can be derived from an ancestral form in which cubitus followed

the course common to *Mnemonica* and *Rhyacophila*, if we assume an anastomosis of *M* and *Cu*, obliterating the posterior arculus (such as Comstock shows has taken place in a species of *Rhyacophila*) to have proceeded to the base of the wing. This view is strengthened by the course of the persistent cubital trachea in the fore wing of a specimen of *Nepticula platanella* (a comparatively generalized species of its genus) which follows the first anal vein at the base, bending obliquely toward media which it reaches at the point where media bends upward toward radius, then extending longitudinally along the usual course of cubitus. The venation of the hind wing shows an advance over that of the fore wing, even in the most generalized Nepticulidæ, in that media and radius coalesce for half their length; this condition, which is brought about by the crossing over of media to radius at the base has been attained in part of the genus *Nepticula* in the fore wing.

In the Hepialidæ the course of cubitus of the fore wing is the same as it is in the Micropterygidæ. In the hind wing *Cu* is free from *1st A* at its base; there is no evidence from pupal wings or adult forms to indicate how this condition may have been derived from one in which *Cu* follows the same course as in the fore wing.

The coalescence of the tips of two branches of the third anal vein with the tip of the second anal vein of the fore wing is a character common to both the more generalized Trichoptera and Micropterygidæ. The second branch of the third anal vein tends to disappear very early in phylogeny, although the third anal trachea is often forked in the pupa. Even in the most primitive Micropterygidæ, as *Sabatinca*, this coalescence of veins is shown in one species and not in the other. The second branch of the third anal vein is but faintly shown in *Epimartyria* (Fig. 1). In *Scoliaula* of the Nepticulidæ, there is a faint indication of a second branch of the third anal vein, represented merely by a broad slight thickening of the wing membrane, but neither it nor the first branch continue far enough to unite with the second anal vein. In Hepialidæ, the second branch of the third anal vein shows no tendency to unite with the first branch, but runs close to the margin of the wing. Among the Frenatæ, the condition of the branches of the third anal vein in *Prionoxystus* is similar to that in Hepialidæ.

In *Prionoxystus robiniæ*, the second branch of the third anal closely parallels the axillary furrow; the third branch follows the free margin of the posterior lobe. As shown later, the inner margin of the fore wing in this species clasps the costa of the hind wing. In other Frenatæ, I have found no indication of the presence of the second branch of the third anal vein. It is suggested as a plausible explanation of the atrophy of this vein that its disappearance is correlated with the loss of the holding function by this part of the wing.

The cross-vein between the first and second anal veins of the fore wing, which is present in Micropterygidæ and Trichoptera, is preserved in many of the primitive Frenatæ as well as in the Hepialidæ. It is shown distinctly in *Adela bella* (Fig. 5), and in *Prodoxus;* in a pupal wing of *Pronuba* this vein is as strong as the second anal. It is shown faintly in *Cyanauges cyanella*.

In the hind wing, the course of the second anal vein, which anastomoses with the first anal vein for a distance, is regarded by Comstock as a distinctly ordinal character, common to Micropterygidæ and Trichoptera (cf. The Wings of Insects, p. 310). The tracheation in the base of the hind wing of *Prodoxus* (Fig. 3), shows the same course of the second anal. The trachea of the second anal vein bends forward to the first anal vein, but almost immediately bends obliquely backward and after meeting the cross-vein between the second and third anal, extends in a longitudinal direction to the wing margin. The cross-vein is a much more distinct and well developed tubular vein than is the base of the second anal vein itself. The pupal tracheation of *Prodoxus* (Fig. 6) shows quite clearly the anastomosis of the first and second anal veins. In this instance the longitudinal cross-vein between the second and third anal veins is preceded by a trachea, which is apparently the first branch of the third anal itself. A similar condition is indicated by the course of these veins in *Cyanauges* and in *Adela;* in neither is verification possible through persistence of tracheæ. In *Adela* the base of the *2nd A* followed proximad, becomes indistinct before reaching the *1st A;* the cross-vein is quite distinct.

In Hepialidæ neither venation nor tracheation in the pupal wings (MacGillivray, '12), where there are three free anal tracheæ, indicates any such anastomosis.

Adela bella (Fig. 5) shows a branching of the third anal vein of the hind wing, similar to that in Micropterygidæ and Trichoptera.

It has just been shown that certain essential features of venation common to Micropterygidæ and Trichoptera and seemingly found in no other insects can be identified in more or less modified form in most of the more primitive Lepidoptera. In most cases the steps in this process of modification can be traced. The evidence is perhaps least satisfactory in the Hepialidæ, which would indicate their divergence from the other lepidopterous groups, a view borne out by other points of structure. It is apparent that these characteristic features of venation which the Micropterygidæ hold in common with the Trichoptera do not distinguish them from the rest of the Lepidoptera as sharply as might be inferred by a comparison of the Micropterygidæ with more specialized Lepidoptera only. The manner of specialization in the Nepticulidæ, with respect to the course of cubitus, is of especial value in determining the true phylogenetic relationship of the Micropterygidæ to the rest of the Lepidoptera. The course of modification in the more generalized Nepticulidæ, paralleling that sometimes occurring in Trichoptera, which is a divergence from the usual lepidopterous type, together with the possession of the fibula, undoubtedly indicates a common ancestry with Trichoptera, while certain other typically lepidopterous characters, such as the single spined frenulum of the male, the short tongue and six-jointed maxillary palpi characteristic of many primitive Frenatæ, obsolescence of the first anal vein of the fore wing, the reduction of radius of the hind wing in the same manner as it has taken place in the Frenatæ, place the Nepticulidæ with certainty in the Lepidoptera. This peculiar combination of characters in the Nepticulidæ, taken in connection with the undoubted specialization in venation, places them as the end group of a line of development divergent from that of the other Lepidoptera. Since these two *divergent* lines of development are both lepidopterous, the common ancestor must also be lepidopterous. It has just been shown, that the course of modification in venation in both lines of development can be traced back to Micropterygidæ, which therefore, on the basis of evidence derived from a study of venation, must be regarded as the common ancestor and is hence lepidopterous. To

remove the Micropterygidæ from the Lepidoptera, would necessitate the assumption that the Lepidoptera have originated twice or have been derived from a hypothetical lepidopterous ancestor so close to Micropterygidæ that it can not be separated from Micropteryidæ.

(*b*) *Mode of Insuring Synchronous Action of Fore and Hind Wings.*

The methods of holding the fore and hind wings together in flight show characteristics which are of value in a study of the phylogeny and relationships of the Trichoptera and Lepidoptera.

In the more generalized Trichoptera and in the most primitive groups of Lepidoptera, the posterior lobe of the fore wing has been modified to serve as an organ for holding the wings together, termed fibula or jugum, depending on mode of functioning. The fibula in the more generalized Trichoptera, such as Rhyacophila, and in certain of the Micropterygidæ, as *Mnemonica* in the subfamily Eriocraniinæ, acts by pressing downward over the base of the hind wing and clasping the anterior tuberosity of the hind wing. Tillyard ('18, '19) has described for certain genera of the two remaining subfamilies of the Micropterygidæ, the Mnesarchaeinæ and the Micropteryginæ, a different mode of functioning of the fibula. In these genera it is described as being bent under the fore wing and serving as a retinaculum for the series of costal spines of the hind wing.* My observations on *Epimartyria* in the subfamily Micropteryginæ tend to support this view.

The fibula in the female of the last specialized genera of Nepticulidæ (which find their nearest allies in characteristics of venation among the Hydroptilidæ in the Trichoptera) is identical in structure with the fibula in the more primitive Trichoptera and in the Micropterygidæ. In the Trichoptera the process of modification of the fibula has finally resulted in such a reduction in size and change in shape that the posterior lobe of the fore wing no longer bears any resemblance to a fibula and can not function to aid in holding the fore and hind wing together. In some forms, while not retaining the characteristic shape shown in the Rhyacophilidæ, the longitudinal free margin still shows the downward curve, thus indicating

* That these spines do not constitute a true frenulum and are not homologous with it, is shown in the pages following.

that it can still act by clasping the anterior tuberosity of the hind wing. The course of modification of shape in the posterior lobe of the fore wing in Nepticulidæ from a fibula in females of the more generalized genera can be traced through various changes until it becomes merely a narrow lobe whose free margin is continuous with the inner margin of the wing. Thus we find that while in the females of earlier genera the fibula has preserved its original structure and is apparently functional, in the males of these genera the posterior lobe is rather prominent but lacks the characteristic shape of the fibula as found in the Trichoptera and Micropterygidæ. In *Nepticula* the posterior lobe has lost all resemblance to the fibula; it is extremely narrowed and the axillary furrow is so indistinct as scarcely to separate it from the rest of the wing. This process, whose steps can be observed in this lepidopterous family, would seem to indicate the possibility that a similar process might have taken place in families of the Frenatæ, or in other words, that the Frenatæ have been evolved from ancestral forms in which a well developed fibula was present. There is some evidence to support this view. In *Prodoxus* the posterior lobe of the fore wing is more than usually prominent and is separated from the rest of the wing by a very distinct axillary furrow; it shows a strong tendency to fold under, thus seemingly retaining some of the function of the fibula, although it has lost its characteristic shape. In some Tineidæ, the posterior lobe of the fore wing bears some resemblance to a fibula, but it is not of a structure to be functional. In others of the Frenatæ where it can be distinguished, it is merely a narrow lobe whose free margin is continuous with the inner margin of the wing.

In the Hepialidæ the jugum, though homologous with the fibula, differs from it in shape and method of functioning. The difficulty in the way of deriving the Hepialidæ from ancestors with a fibula disappears if a process similar to that which is known to take place in the Nepticulidæ is postulated. The jugum, in accordance with this view, would be considered a development in another direction from the posterior lobe of the fore wing in a more or less reduced condition.

The fact that a fibula of identical structure, though showing some variation in function, is present in three different groups, two of which, the Micropterygidæ and Rhyacophilidæ, are primitive and approach one another closely in other char-

acteristics of the wings, indicates that it is a persistent primitive character handed down from the common ancestor. The Nepticulidæ show marked specialization and are the end of a line of development, having given rise to no other group. Though they are not apparently to be easily or directly derived from any existing group, the possession of this primitive character undoubtedly allies them more closely to the Micropterygidæ than to any other Lepidoptera, and also indicates trichopterous affinities. However, the possession by Micropterygidæ and Nepticulidæ of this character of primitive Trichoptera, while it indicates relationship to Trichoptera, need not be taken as a basis for regarding them as trichopterous insects, because as shown for Nepticulidæ, it has disappeared as a functional structure in males even of the less specialized genera, and its function has been taken over by a single-spined frenulum of a character typical of the males of the more specialized Lepidoptera. That is, the Nepticulidæ retain evidence of descent in the form of a fibula, but they have progressed far enough in the lepidopterous direction to have developed a distinctly lepidopterous structure. The undoubted relationship between the Nepticulidæ and the Micropterygidæ indicates that the Micropterygidæ are without doubt also lepidopterous, but being a more primitive group, have not traveled thus far toward the usual lepidopterous type in respect to mode of uniting the wings.

In Rhyacophilidæ and other groups of the Trichoptera, in Micropterygidæ, Nepticulidæ and many of the more primitive Frenatæ (Figs. 1, 2, 5, 4a, 8), there is a series of slightly curved stiff spines on the costa of the hind wing near the base, which lie against one of the anal veins of the fore wing, or catch into a similar series on the fore wing, or lie in the fold of the fibula, and aid in holding the wings together. These spines lie beyond the costal sclerite, not on it, as do the true frenulum spines. They are proximal to the humeral vein in forms where this vein is present. This series of spines is without doubt homologous in the various groups in which it occurs; it may be present in addition to other means of holding the wings together, or it may be the only method of insuring united action of fore and hind wings. It may be functional in females, while in the males of the same species its function has been taken over by some other structure. Thus in Nepticulidæ (Braun, '17),

these costal spines are functional in females, but in the male, where there is a single spined frenulum, they are rarely preserved with the same structure and function. In Nepticulidæ when functional, they are larger and stronger than in any other Lepidoptera (except perhaps *Opostega*); they are decidedly stronger than in the Micropterygidæ. The spines are present in several of the more primitive frenate lepidopterous groups, often in combination with other primitive characters, and sometimes persist in more specialized groups. In the females of many groups of Lepidoptera this is the only method of insuring the united action of the fore and hind wings. These spines are present in females in Prodoxidæ, Adelidæ and Incurvariidæ, together with a few weak and useless short spines in the position of the frenulum. Homologous structures much modified and without function of holding may be distinguished in the males in these families, together with a well developed single-spined frenulum. In many genera of *Lyonetiidæ* they persist particularly in the female where there is also a functional frenulum, and they may also be distinguished as definite structures in the male, different from the rest of the scale covering of the wing. It is questionable whether they are functional except in rare instances in this family.

The possession of the row of costal spines by many of the Trichoptera and by more primitive Lepidoptera indicates that it is a persistent primitive character, and as such indicates common descent of the two groups. The preservation of these spines in many frenate Lepidoptera is one of the few connecting links between them and the Micropterygidæ.

The series of costal hooks — the hamuli — which have developed in the more specialized families of Trichoptera as a means of locking the fore and hind wing together, is a specialization not found in the Lepidoptera.

The true frenulum spines are situated on the costal sclerite of the hind wing. Although structures homologous with a frenulum, consisting of several stiff spines on the costal sclerite of the hind wing are found in some of the more specialized Trichoptera, the frenulum in its specialized form, culminating in the single-spined frenulum with the well developed frenulum hook of the male, is a distinctly lepidopterous development. In most Trichoptera, in Micropterygidæ, in females of Nepticulidæ, in females of *Prodoxus*, *Adela*, etc. (Figs. 1, 2, 5, 4a, 8),

there are merely hairs or weak functionless setæ on the frenulum-bearing area; in these the function of holding the wings together is performed by some other structure. In the males of some of these, viz., Nepticulidæ, *Prodoxus*, *Adela*, etc., there is a strong single-spined frenulum, formed by the fusion of several spines, in some instances of as highly specialized a character as is found in any Lepidoptera. These forms furnish no evidence of the phylogenetic process of development of the frenulum or frenulum hook, but such evidence is furnished by the condition of the frenulum in some members of several groups which conserve other primitive characters. In Cossidæ and Megalopygidæ the frenulum is in a rudimentary condition, consisting of a bunch of spines, and in the females of many moths it consists of two or several spines. Of the process of transition from more primitive modes of holding the wings together to a functional frenulum, we have very little evidence. In this connection, the condition found in *Pronuba* is significant. In the female *Pronuba yuccasella* all except the two most proximal of the row of costal spines have become flattened and scale-like, and these two remaining spines are larger than any of the corresponding series found in *Prodoxus*, which is an allied, though more generalized genus. In addition in the female *Pronuba* the beginnings of a true frenulum are shown, consisting of a tuft of short, weak spines at the distal end of the costal sclerite in the same position as the frenulum of the male. There is also an inwardly projecting row of scales from the costa of the fore wing, apparently the beginning of a frenulum hook, which is present in the male. The female frenulum is not long enough to reach this row of scales, which is, however, easily reached by the two strong costal spines, which may thus *function* as a frenulum before the true frenulum has reached a sufficient size to be functional. These two spines are not present in the male *Pronuba*, which has a single-spined frenulum. In the Nepticulidæ there is no stage in the development of the frenulum intermediate between the minute functionless spines of the female, and the strong single-spined frenulum of the male. However, the fact that functional costal spines and frenulum are occasionally present at the same time, indicates that the costal spines retain their function up to the time that it is taken over by the frenulum. In the Cossid, *Prionoxystus robiniæ*, where the frenulum is rudimentary in both sexes, the

underside of the inner margin of the fore wing hooks against a strong ridge along the costa of the hind wing.

It is apparent then that a functional frenulum has originated independently in the Lepidoptera, and that it is not a primitive character derived from the ancestral lepidopterous stalk.

From the facts as above stated, it is equally apparent that the transition from more primitive modes of holding the wings together has taken place within the Lepidoptera, although in most cases the intermediate stages have not been preserved. That the frenulum originated independently several different times at least in the Lepidoptera is shown, first, by the fact that it appears in the Nepticulidæ, which is an end group not derived from or related to the frenate Lepidoptera; second, by the fact that it takes the place of costal spines in *Pronuba;* third, by the specialized condition of the frenulum in the males of certain groups, the females of which have a very rudimentary frenulum; fourth, by its rudimentary condition in other comparatively primitive groups, such as the Cossidæ, where there is no evidence of costal spines or similar holding structures, and the transition stage has been bridged by a very different means. It may have originated independently in other families, but we are without direct evidence to this effect; similarly it may have disappeared independently as is shown for example by its presence in *Euschemon* only, in the Hesperidæ.

The significant phylogenetic feature in the development of the frenulum is its appearance in the Nepticulidæ which is the end of a line of development, and which is related to Micropterygidæ and must be regarded as derived from them, and its independent appearance in the group usually known as the Frenatæ. No similar course of development is to be witnessed in the Trichoptera. The evidence for phylogeny derived from the frenulum in my view points unmistakably to the conclusion that the branch of the ancestral stem which produced Micropterygidæ and Nepticulidæ must also have given rise to the rest of the Lepidoptera and hence all should be included in one order.

(*c*) *Distribution of Fixed Hairs.*

A character, which when present, may without doubt be regarded as a persistent primitive character is the presence of the fixed hairs upon the wing surface. These are characteristic

of the Trichoptera, the Micropterygidæ and certain other of the more primitive families of the Lepidoptera, Nepticulidæ, Hepialidæ, Incurvariidæ, etc., where they are distributed over the entire wing surface, but even in these most plentiful on the underside of the fore wing near the dorsal margin. In many Lyonetiidæ, e. g., *Hieroxestis*, *Oinophila*, *Coptodisca*, besides the fixed hairs on the underside near the inner margin, there is a patch in the middle of the fore wing near the base; in *Tischeria* and *Opostega*, there are additional scattered fixed hairs on the wing surface. In other groups the fixed hairs are confined to the under side of the fore wing near the base of the dorsal margin, with the rare presence of such hairs on other parts of the wing, e. g., in *Tineola*. The very fact that the fixed hairs are most numerous in the most primitive groups, tending to become scattered and later confined to definite areas of the wing, and finally persisting only in a limited area on the underside of the fore wing, where they may function to a slight degree in holding the wings together in flight, shows that while taken in connection with other characters, their presence may indicate a comparatively primitive condition of the forms possessing them, the character is not one upon which a taxonomic division can be made.

III. Summary and Conclusions.

The discussion of wing structure in Lepidoptera has dealt chiefly with those characters which have been handed down from the common ancestor of both Lepidoptera and Trichoptera, and which have been preserved without modification in the most primitive Lepidoptera, but which have undergone more or less far-reaching modification in all other groups of Lepidoptera. In many instances the steps in the process of modification have been traced, and it has been possible to identify these characters in their modified form in many of the more primitive groups of frenate Lepidoptera. These changes in structure have sometimes been correlated with changes in function of certain parts of the wing or with the taking over of a particular function by a different organ.

The conclusion reached from a study of certain features of venation is that the Micropterygidæ are not as sharply separated from the rest of the Lepidoptera as might be inferred from a

comparison made only with more specialized groups of Lepidoptera. The modifications which are shown in the more primitive groups of frenate Lepidoptera have their beginnings in the Micropterygidæ themselves. In addition we have the evidence given by the Nepticulidæ, which combine in one group, certain characters found in the Frenatæ, with characters belonging to the Micropterygidæ and in the manner of specialization of certain characters of venation diverge from all other Lepidoptera, paralleling what occurs in some Trichoptera. The existence of these *divergent* groups, the Frenatæ and the Nepticulidæ, both of which are derived from Micropterygidæ, is conclusive evidence of the lepidopterous character of their common ancestor, the Micropterygidæ, even if we do not take into consideration such features of the Micropterygidæ as the character of the mouth-parts and the scale covering of the wings, which unmistakably stamp them as lepidopterous.

The conclusion drawn from a study of the various modes of holding the wings together in flight in the Lepidoptera, is that in the more primitive groups of Lepidoptera, including the Micropterygidæ, certain trichopterous structures are retained and are functional, but in higher groups are modified or disappear and their function is taken over by other wing structures, chief of which is the frenulum. The frenulum in its specialized form is shown to have had its origin in the Lepidoptera and to have developed independently in several widely separated groups.

Certain general phylogenetic and taxonomic conclusions follow from these studies. The Micropterygidæ are close to the common ancestor of both Lepidoptera and Trichoptera, but are true Lepidoptera. From them the remaining Lepidoptera have been derived, not from a single line of descent, but from several divergent lines, one of which is represented by the Nepticulidæ alone; a second line by the Hepialidæ, with the Prototheoridæ apparently forming a link between it and the Micropterygidæ, and to which the Cossidæ show some degree of relationship; a third much branched line includes the frenate Lepidoptera, of which some members such as the Prodoxidæ, Incurvariidæ, etc., conserve some of the trichopterous characters of their ancestry and must therefore be regarded as the most primitive of the Frenatæ.

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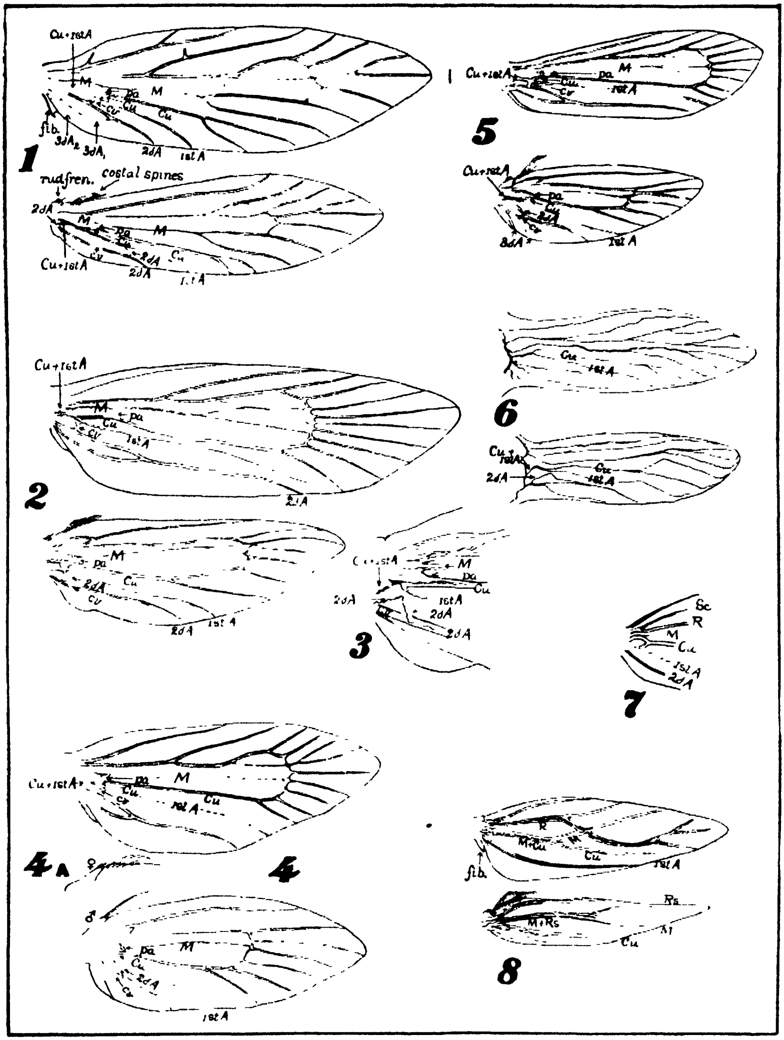
EXPLANATION OF PLATE XXIX.

Fig. 1. Wings of *Epimartyria auricrinella.*
Fig. 2. Wings of *Prodoxus quinquepunctellus*, female.
Fig. 3. Base of hind wing of *Prodoxus quinquepunctellus*, female.
Fig. 4. Wings of *Cyanauges cyanella*, male; 4a, base of costa of hind wing of female.
Fig. 5. Wings of *Adela bella*, female:
Fig. 6. Tracheation of pupal wings of *Prodoxus quinquepunctellus.*
Fig. 7. Base of fore wing of *Renia flavipunctalis.*
Fig. 8. Wings of *Ectoedemia heinrichi*, female.



Annette F. Braun

THE LIFE HISTORY AND EARLY STAGES OF PLATYMETOPIUS HYALINUS OSB.,* A JAPANESE MAPLE LEAF-HOPPER IN NEW JERSEY.

By EDGAR L. DICKERSON and HARRY B. WEISS,
New Brunswick, N. J.

For the past several years the writers have noted this species as occurring more or less abundantly on Japanese maple (*Acer palmatum* Thunb.) in various places in New Jersey, principally South Orange, Plainfield, Springfield, Irvington and Rutherford. During the summer of 1918 it was very abundant at Freehold, N. J., on a form of Norway maple (*Acer platanoides* L. var. *globosum* Nich.) and the following notes are the results of observations made at that locality.

The species overwinters in the egg stage, each egg being deposited singly just under the bark close to a bud on the recently made growth of the twig. The egg is firmly embedded in the tissue which becomes brownish and somewhat hard adjoining it. The outer bark over the egg is raised and somewhat cracked and a crack is also present where the egg is inserted. Sometimes the end of an egg protrudes slightly. The egg is inserted so that its long axis is more or less at right angles to the tissue and a favorite place for deposition is the thickened part of the twig around the buds. Sometimes eggs were found in groups of two to five each egg being separated from the other, however, by considerable tissue.

At Freehold, N. J., hatching took place about the first of June and continued for almost a month. As late as early July it was possible to find first stage nymphs. From eggs hatching the first few days in June, adults appeared the first few days of July, showing that about one month is necessary for the development of the five nymphal stages. This is probably the maximum time and would be shortened by very warm weather. On account of the uneven hatching of the eggs, it is possible to find all nymphal stages and adults present during the first part of July. By the end of July practically all of the nymphs have matured and at this time and during the first of August the adults are most plentiful. Over-

* Identified by E. P. Van Duzee.

wintering eggs are then deposited. The nymphs feed on the lower leaf surfaces and seem to prefer the shaded portions of the tree. The adults are very active, move readily when the leaves are disturbed and when numerous their activity results in sounds like rain falling on the leaves.

EGG—Length 0.9 mm. Greatest width 0.18 mm. Translucent, subelliptical, somewhat flattened and not quite cylindrical, tapering slightly to both ends, one end rounded, the other end, at the surface of the tissue, truncate.

FIRST NYMPHAL STAGE—Length, including anal processes, 1.1 mm. Width of head, including eyes, 0.29 mm. Elongate-elliptical; very light yellowish white; beginning just behind the eyes there is a reddish-brown, lateral margin varying in width and extending dorsally on prothorax, posterior margin of thorax and anterior margin of abdomen and on some of posterior abdominal segments (interrupted in some specimens); antennæ slightly longer than body; head extending forward, triangular, obtusely angled in front, sides slightly rounded; eyes lateral, prominent; insect widest across eyes; sides of body slightly rounded and tapering to posterior end of abdomen; posterior end of abdomen divided into two minute, spine-like processes; abdominal lateral row of hairs similar to row on second stage; (dorsal hairs not apparent); rostrum extending to beyond bases of second pair of legs; indications of spines on tibia.

SECOND NYMPHAL STAGE—Length, including anal processes, 1.85 mm. Width of head, including eyes, 0.36 mm. Shape narrow, more elongate than that of first stage. Color varies from sordid white to light yellow. Lateral reddish-brown margin somewhat similar to that of first stage, but varying and somewhat broader. Antennæ three-fourths length of body. Head similar to that of first stage; sides of thoracic segments rounded; metathorax slightly longer than lengths of pro- and mesothorax combined; broadest across metathorax; abdomen slightly narrow at base, widening to second abdominal segment and gradually tapering to posterior part; spine-like processes one and one-half times as long as last abdominal segment and bearing several hairs; each abdominal segment bears two dorsal and two subdorsal and in addition the last three segments two lateral hairs; rostrum extending to between bases of second pair of legs; two rows of hair-like spines on outer margins of hind tibia.

THIRD NYMPHAL STAGE—Length, including anal processes, 2.9 mm. Width of head, including eyes, 0.44 mm. Somewhat similar to preceding stage; eyes more prominent; lateral reddish-brown markings more extended, in some specimens much extended on dorsal surface leaving a dorsal, median band of ground color of varying width (markings vary considerably in different individuals); anterior margin of head slightly more angulate; posterior margin of prothorax arcuate, outer posterior angles margined; mesothorax twice as long at sides as at middle; metathorax twice as long as pro- and mesothorax combined, posterior

margin subtruncate, scarcely longer at sides than at middle; abdominal hairs similar to those of fifth stage nymph; posterior abdominal spine-like processes equal in length to the two posterior abdominal segments; rostrum extending to between bases of second pair of legs.

FOURTH NYMPHAL STAGE—Length, including anal processes, 4.1 mm. Width of head, including eyes, 0.58 mm. Shape somewhat similar to that of fifth stage; dorsal and lateral reddish-brown markings somewhat similar to those of preceding stage, but more diffused, in some specimens extending further medially on dorsal surface of head and some of body segments; antennæ about one-half length of body; eyes prominent, lateral, extending slightly posteriorly; anterior margin of head subacute, sides slightly rounded; prothorax rounded in front to conform to posterior margin of head, posterior margin slightly curved and slightly wider than anterior margin; mesothorax with lateral margins decidedly elongate covering two-thirds of metathoracic lateral margins; metathorax with lateral margins somewhat elongate, covering part of first abdominal segment; abdomen broadest across second segment gradually tapering to end; length of posterior abdominal spine-like processes more than combined lengths of last two abdominal segments; spine-like processes bearing long hairs; abdominal hairs similar to those of fifth stage nymph; rostrum extending almost to bases of second pair legs; few, minute spines on legs; hind tibial spines similar to those of fifth stage.

FIFTH NYMPHAL STAGE—Length, including anal processes, 5.5 mm. Width of head, including eyes, 0.78 mm. Elongate-narrow; vertex acutely pointed and abdomen gradually tapering from anterior portion to apex; color sordid white with dorsal and lateral surfaces and wing-pads mottled with a number of orange-yellow spots often margined with interrupted reddish-brown lines, spots vary in size and some tend to form one or two dorsal rows; antennæ more than twice the length of the head, situated on front just below eyes; head acutely pointed, posterior margin arcuate, eyes prominent, extending backward, forming outer posterior angles; head as long as width of broadest portion of head across eyes; prothorax rounded in front to conform to the posterior margin of head, posterior margin slightly curved, slightly wider than widest portion of head across eyes; mesothorax about as wide as prothorax; median portion of mesothorax about one-half as long as width, sides somewhat shorter; wing-pads long, narrow and extending to posterior margin of first abdominal segment. Metathorax about as long as mesothorax; wing-pads extending slightly beyond those of mesothorax; abdomen widest across anterior end and gradually tapering to last segment which is terminated by two, long, spine-like processes, which equal in length the combined lengths of the last three segments; each abdominal segment bears near its posterior margin two dorsal and two subdorsal and beginning with the third segment, two additional lateral, fine, long hairs which are equidistant; posterior spine-like processes also bear a number of fine, long, hairs; ventral surface and legs sordid white; rostrum extending beyond bases of first pair of legs; hind tibia bearing a row of hairs on inner margin and a double row of spine-like hairs on outer margins; few minute spines on legs.

ADULT—*Platymetopius hyalinus* Osborn. This was described by Osborn in 1900 (Ent. News, vol. XI, p. 501) from five females and four males collected in Washington, D. C., June, 1897, by Mr. J. S. Hine, who stated that they were very abundant upon an introduced species of maple. As this description is available to most entomologists, there is no need to repeat it here. It might be stated, however, that the insect can be recognized due to the fact that it is quite distinct from any other species of the genus occurring in this country. In Osborn's description it is characterized as follows: "Elytra hyaline with dark points and fuscous bands arranged, one subbasal, one median and one subapical. Face bright, sulphur-yellow, vertex, pronotum and scutellum yellow, with some infuscations or greenish washes. Length, female, 5.5 mm.; male, 4.25 mm."

Van Duzee, in his "Revision of the American Species of Platymetopius," (Annals Ent. Soc. Amer., vol. 3, 1910, p. 218), states that "this insect is quite aberrant in its genus by its uniformly whitish hyaline elytra crossed by three narrow fuscous bands. Prof. Osborn described it from a series taken from an imported tree at Washington, D. C., and strongly suspected that it might be an exotic form introduced from material added to the Botanical Gardens there. In that case it probably has become acclimated as Mr. C. W. Johnson has sent me a specimen he took near Philadelphia."

While Pennsylvania and the District of Columbia are the only localities listed in Van Duzee's Catalogue, it probably occurs in many other eastern places in view of the wide distribution of the Japanese maple as an ornamental tree. We believe that Prof. Osborn's surmise that this is an introduced species is correct and that it has been brought into this country on imported maples. This is quite possible in view of the fact that overwintering takes place in the egg stage in the twigs.

THE PREVALENCE OF PHORMIA AZUREA FALLEN (LARVA PARASITIC ON NESTLING BIRDS) IN THE PUGET SOUND REGION AND DATA ON TWO UNDESCRIBED FLIES OF SIMILAR HABIT.

By O. E. Plath.

(Together with Descriptions of the Two New Flies by C. H. T. Townsend and J. M. Aldrich.)

In two recent papers[1] the writer pointed out that the larvæ of *Phormia*[2] *azurea* Fallen habitually suck the blood of nestling birds, sometimes with fatal results, and that the adult flies, contrary to the opinion of most dipterists, are quite abundant, at least in the San Francisco Bay Region. Last summer (1918), while visiting Seattle, he had occasion to ascertain whether *Phormia azurea* Fallen also occurs in the Puget Sound Region and found that it is as frequent there as in the San Francisco Bay Region. During his stay at Seattle (June 15th to August 1st), fifty-four birds' nests were examined containing nestlings belonging to ten different species of birds. Of these fifty-four nests, thirty-three were infested by the larvæ of *Phormia azurea* Fallen,[3] one by those of a new species of *Phormia*, and six by those of a new fly belonging to the genus *Hylemyia* of the family Anthomyidæ. Drs. J. M. Aldrich and C. H. T. Townsend, of the United States Bureau of Entomology, have been kind enough to describe the two new flies, the descriptions being appended to this paper, and the two flies will hereafter be referred to as

[1] Plath, O. E. (a) Parasitism of Nestling Birds by Fly Larvae. The Condor, Vol. XXI (1919), pp. 30–39. (b) A Muscid Larva of the San Francisco Bay Region which Sucks the Blood of Nestling Birds. Univ. Calif. Publ. Zool., Vol. XIX (1919), pp. 191–200.

[2] A synonym of *Protocalliphora* which Dr. C. H. T. Townsend of the United States Bureau of Entomology considers more appropriate.

[3] A large number of specimens of this fly were sent to Dr. C. H. T. Townsend of the United States Bureau of Entomology who has informed me that the fly was correctly identified by Mr. C. W. Johnson (Cf. a. The Condor, Vol. XXI, p. 34. b. Univ. Calif. Publ. Zool., Vol. XIX, p. 194. Dr. Townsend has also called my attention to the fact that Coutant's fly (Cf. Coutant, A. F., The Habits, Life History, and Structure of a Blood-sucking Muscid Larva (*Protocalliphora Azurea*). Jour. Parasit., Vol. I, pp. 135–150) is not *Protocalliphora* (*Phormia*) *azurea* Fallen, as was claimed by Coutant, but *Phormia chrysorrhea* Meigen. This fact, Dr. Townsend thinks, may account for the disparity between Coutant's observations and mine (Cf. The Condor, Vol. XXI, p. 37. b. Univ. Calif. Publ. Zool., Vol. XIX, pp. 198–199).

Phormia metallica Townsend[4] and *Hylemyia nidicola* Aldrich. The frequency with which the larvæ of *Phormia azurea* Fallen were encountered in birds' nests, and the number of larvæ and pupæ per nest, is shown by the following tables:

TABLE I.

Species of Bird	Nests examined	Infested nests	Uninfested nests	Infestation
Nuttall Sparrow (*Zonotrichia leucophrys nuttalli* Ridgway)............	3	3	0	100%
Rusty Song Sparrow (*Melospiza melodia morphna* Oberholser).......	2	2	0	100%
Willow Goldfinch (*Astragalinus tristis salicamans* (Grinnell)...........	2	2	0	100%
Oregon Towhee (*Pipilo maculatus oregonus* Bell).....................	1	1	0	100%
Russet-backed Thrush (*Hylocichla ustulata* (Nuttall)...................	5	4	1	80%
Western Robin (*Merula migratoria propinqua* (Ridgway).............	25	18	7	72%
Cedar Waxwing (*Ampelis cedrorum* (Vieillot).........................	3	1	2	33%
Yellow Warbler (*Dendroica aestiva* (Gmelin)...........	5	1	4	20%
Cliff Swallow (*Petrochelidon albifrons* Say).......................	7	1	6	14%
English Sparrow (*Passer domesticus* Linnaeus)........................	1	0	1	0%
Totals..................	54	33	21	61% ;Average

[4] A species closely related to *Phormia chrysorrhea* Meigen, the latter, according to Dr. Townsend, being synonymous with *Phormia sordida* Zetterstedt and *Phormia splendida* Macquart.

TABLE II.

Species of Bird	Larvae in Each Nest	Totals	Larvae per Nest
Nuttall Sparrow (*Zonotrichia leucophrys nuttalli* Ridgway)	39, 40, 87	166	55
Rusty Song Sparrow (*Melospiza melodia morphna* Oberholsder)	52, 55	107	53
Cliff Swallow (*Petrochelidon albifrons* Say)	47	47	47
Oregon Towhee (*Pipilo maculatus* Bell)	45	45	45
Willow Goldfinch (*Astragalinus tristis salicamans* (Grinnell)	28, 59	87	43
Yellow Warbler (*Dendroica aestiva* (Gmelin)	39	39	39
Western Robin (*Merula propinqua* (Ridgway)	7, 11, 15, 16, 18, 18, 21, 23, 26, 27, 27, 29, 37, 39, 40, 43, 72, 138	607	33
Russet-backed Thrush (*Hylocichla ustulata* Nuttall)	22, 27, 28, 31	108	27
Cedar Waxwing (*Ampelis cedrorum* (Vieillot)	2	2	2
Totals		1208	36 Average

All of these nests, excepting eight, were located in shrubs and trees three to twenty feet above ground, while the remaining eight came from an altitude of about forty feet. Seven of the latter (the Cliff Swallow nests) were taken from below the eaves of a two story building on the campus of the University of Washington, and the remaining one (that of the English Sparrow) from a box near the top of a high telephone pole. The comparatively small percentage of infestation of these eight nests might of course be a coincident, but it is perhaps more probable that it was due to the location and structure of the nests.

The thirty-three nests infested by the larvæ of *Phormia azurea* Fallen contained 111 nestlings. Although many of the larvæ taken from these nests were gorged with blood, only two

of the 111 nestlings died. That there were no more fatalities is perhaps to be explained by the fact that more than half of the thirty-three infested nests were those of comparatively large birds, the Western Robin and the Oregon Towhee.

The nest infested by the larvæ of *Phormia metallica* Townsend was that of a Western Robin and contained three nestlings. When the latter took wing, twenty-six larvæ were taken from the nest. The larvæ pupated in a few days and both larvæ and pupæ looked so much like those of *Phormia azurea* Fallen that the writer was unaware that he was dealing with a new fly until the adults emerged. From the facts at hand it seems probable that *Phormia metallica* Townsend, both as larva and adult, is similar in habit to that of its near relative, *Phormia chrysorrhea* Meigen.

The six nests infested by the larvæ of *Hylemyia nidicola* Aldrich offered an entirely different aspect. When discovered four of them contained the remains (only bones and feathers) of nine, nearly full-fledged nestlings. From these four nests, 283 pupæ were taken nearly all of which later hatched. The remaining two nests infested by the larvæ of *Hylemyia nidicola* Aldrich were those of a Cliff Swallow and a Yellow Warbler and contained one and five dead nestlings respectively. In these two nests the larvæ were still at their repast. Fifty-nine larvæ were picked from the outer surface of the six dead birds, though many more could undoubtedly have been obtained from within the nestlings. None of the six nests infested by the larvæ of *Hylemyia nidicola* Aldrich contained any living nestlings when discovered, but judging by the small number of dead birds in most of the nests, it seems possible that some of the nestlings may have survived.

The larva of *Hylemyia nidicola* Aldrich is much smaller than that of *Phormia azurea* Fallen and measures about 8 mm. in length and 2 mm. in width when mature. It apparently is not blood-sucking in habit like the larvæ of *Phormia azurea* Fallen, *Phormia chrysorrhea* Meigen, and other Muscidæ. The pupa[5] measures about 5 mm. in length and 2.5 mm. in width and is of a glossy, golden-brown color.

[5] It is identical in size and appearance with the seventy-one secured near Berkeley, California, the preceding summer (Cf. a. The Condor, Vol. XXI, pp. 36–37. b. Univ. Calif. Publ. Zool., Vol. XIX, pp. 196–197).

There are only two possible explanations in regard to the relation existing between the dead nestlings and the presence of the larvæ of *Hylemyia nidicola* Aldrich. The first is that the young birds died from some cause or other and that the adult flies were then attracted by the odor of the decomposing nestlings to deposit their eggs, or maggots, on them. The second explanation would be that the eggs, or maggots, were deposited on, or near, the young birds while the latter were still alive, the larvæ subsequently causing the death of the nestlings by penetrating into their body. It has been known for some time that the larvæ of certain species of flies belonging to the genera *Hylemyia* and *Mydaea* of the family Anthomyidæ attack nestling birds in Central and South America,[6] and the second explanation is therefore not an improbable assumption. Should further investigations prove that the larvæ of *Hylemyia nidicola* Aldrich do attack living nestlings, as now seems probable, then it will be important to determine the range and bring this fly under control if we are not to suffer considerable loss among our wild birds.

As regards subcutaneous parasitism of nestling birds by fly larvæ, I should like to relate an interesting experience I had at Seattle, last summer. During my investigations I came across a nest containing six Willow Goldfinches which were nearly old enough to leave the nest. One of these nestlings had a patch of yellow on its head instead of being of the ordinary color. I turned this bird over to a lady in Seattle to have it reared with a brood of canaries. Two or three days later my attention was called to the fact that some of the feathers on the bird's head were standing up and that the young bird was constantly scratching its head. Upon examining the bird I noticed three small holes, one on top and two at the side of its head. Near the opening of each of these holes the anal end of an active fly larva was visible. The larvæ were extracted with considerable difficulty by means of a pair of scissors and forceps, and were about 5 mm. in length and 2 mm. in width.

[6] Cf. (1) Townsend, C. H. T., (a) The Grass-quit Bot, an Anthomyiid Parasite of Nestling Birds in Jamaica. Jour. Inst. Jamaica, Vol. II, pp. 173–174. (b) *Mydaea spermophilae* n. sp. (Larva Parasitic on Nestling Birds). Trans. Amer. Ent. Soc., Vol. XXII, p. 79. (2) Nielsen, J. C., (a) *Mydaea anomala* Jaenn., a Parasite of South-American Birds. Vidensk. Meddel. fra Dansk Naturhist. Foren. Bd. 63 (1912), pp. 195–208. (b) On Some South-American Species of the Genus *Mydaea*, Parasitic on Birds, *ibid.* Bd. 65 (1913), pp. 251–256.

They were similar in appearance to the immature larvæ of *Phormia azurea* Fallen, but showed no blood in their intestines. I tried to rear these three larvæ, but all three died before pupating. The young goldfinch completely recovered from the rather severe operation and is still living (March, 1919).

The study of birds' nests from the viewpoint of the entomologist and parasitologist seems thus far to have been rather neglected. While examining Cliff Swallow nests below the eaves of a two-story building on the campus of the University of Washington, I found them so thickly infested by bed bugs[7] that I preferred to leave the remaining nests alone. Another blood-sucking insect that seems to use birds' nests as a favorable breeding place is the flea. I had encountered numerous flea larvæ in birds' nests near Berkeley, California, the preceding summer (1917), but when I saw the almost increditable multitude of flea larvæ contained in a single sparrow nest which was taken from a box near the top of a high telephone pole at Seattle, I was amazed. In addition to the parasites which I have spoken of as inhabiting birds' nests, two or three others were mentioned in one of my recent papers,[8] and this number will undoubtedly be increased. These facts make it evident that birds' nests offer a fruitful field of investigation for the professional parasitologist.

[7] Very probably *Oecacus* (*Acanthia*) *hirundinis* Jen., a species closely related to the common bed bug, *Cimex* (*Acanthia*) *lectularia* Linnaeus, but more slender than the latter.

[8] Cf. The Condor, Vol. XXI, pp. 35–36.

Description of the New Species of *Phormia*.

By C. H. T. Townsend,
United States Bureau of Entomology, Washington, D. C.

Phormia metallica n. sp.

Length, 7 to 8.5 mm. Twenty-eight specimens, all females; eight pinned from New Hampshire, Virginia, Illinois, Wisconsin; and twenty, of which ten are alcoholic, from Puget Sound, Washington State, reared by Mr. O. E. Plath from maggots taken from nests containing young birds.

Female vertex one-sixth to one-fourth head width. Head brownish, thinly olive-grayish pollinose, with more or less of a brassy tinge. Viewed obliquely from below the whole face appears blackish, with a conspicuous golden spot at upper end of both parafacilia. Antennæ wholly blackish or brown, the third joint one and one-half to two times as long as second. Palpi fulvous to rufous, the tips fuscous. Thorax and scutellum dark metallic greenish-black to bright cupreous or brassy-green, silvery to olive-gray pollinose, leaving three nearly equal and rather heavy vittæ of the ground color. There is a faint narrow dark vitta barely visible in front close on each side of the median vitta in some specimens. Abdomen metallic dark bluish-green to bright cupreous or golden-green, showing thin silvery pollen coat in certain lights, the anal segment always cupreous to golden-green. Legs blackish. Wings clear. Tegulæ white to buff-yellow.

Holotype from Franconia, New Hampshire.

There is a well marked difference in the two forms here described as one species. The typical form, represented from all the above localities, is the darker one, with only the anal segment golden-green, and the tegulæ white. The vertex is about or nearly one-fourth head width, and the length is 7 to 8.5 mm. Thoracic pollen silvery.

The other form, represented by three New Hampshire and four Puget Sound specimens, has the abdomen wholly cupreous to golden-green, the anal segment being concolorous; the thorax and scutellum cupreous to brassy-green, almost the same shade as abdomen; and the tegulæ deep buff-yellow. This form will perhaps prove to be a good subspecies, or it may even be specifically distinct. The front is narrower in this form, the vertex running from one-sixth to little over one-fifth head width, and the length is 7 to 7.75 mm. Thoracic pollen olive-gray.

The Puget Sound specimens, of both forms, have the third antennal joint about twice as long as second, the second joint

being moderately short. The eastern specimens, of both forms, have the second antennal joint longer, and the third joint only about one and one-half times as long as second.

The typical form was identified by Coquillett as *Calliphora splendida* Macquart, and specimens of the other form were included in the series so labeled by him. Macquart's specimen was from Galveston, Texas, and the size was given as five lines or 10 mm. The thorax and scutellum were stated to be black, the abdomen greenish-blue with tip golden. The first two antennal joints were said to be very short, and testaceous in color. Also the wings were said to be fuscous on costal border. On account of these discrepancies, I am unable to identify the present forms as Macquart's species, which appears certainly to be a synonym of *chrysorrhea* Meigen.

Description of a New Species of *Hylemyia*.

By J. M. Aldrich,
United States Bureau of Entomology, Washington, D. C.

Hylemyia nidicola n. sp.

Male—Deep black, with yellow halteres; calypters infuscated, almost black, with the fringe dark below.

Front hardly wider than lower ocellus; six pairs of frontal bristles, beginning at middle; frontal and facial orbits dark, not silvery, narrow; antennæ black, rather large, third joint reaching nearly to edge of mouth, twice as long as second, arista bare; face flat, edge of mouth very little protruding; bucca about one-eighth the eye-height, rather bristly; palpi and proboscis black, ordinary; back of head flat, with coarse black hair.

Thorax deep black, rather velvety above, with a trace of paler pollen at inner edge of humerus each side; two to three pairs of large anterior acrostichals, three posterior dorsocentrals, three sternopleurals; metanotum with gray pollen; pteropleura and hypopleura without hairs.

Abdomen black, with a faint, interrupted lighter pollinose cross-band on each segment and a median dark stripe; fifth sternite with deep excision and two long black lobes, which do not bear any striking bristles.

Genitalia rather small; first genital segment shining black, with about twenty small bristles; second segment subshining, with ordinary hairs directed backward; inner forceps united, short, beadlike, with two long hairs on each side near tip; outer forceps dark brown, shining, twisted, not long, rounded at tip.

Legs wholly black, without striking characters, pulvilli a little enlarged, brownish; front tibia with one or two bristles on outer hind

side; middle tibia with one on outer front, one on outer hind, and two on inner hind side; hind tibia with two on outer front, six on outer hind, three on inner hind, and a few cilia on basal half.

Wings uniformly blackish-brown; costal spine almost wanting; last section of fourth vein one and a half times the preceding.

Female—Color rather uniform dark gray; front almost one-third the head width; cruciate bristles present; abdomen uniform gray, sub-shining; chaetotaxy as in male. Calypters yellow, with pale fringe; wing not infuscated.

Length, 4 mm.

Locality, Seattle, Washington.

Type, male, allotype, female, and one paratype female, deposited in United States National Museum (Type No. 22131). Paratype male and female deposited in the California Academy of Sciences.

The species shows the usual characters of *Hylemyia*—sixth vein reaching wing-margin, scutellum with delicate hairs below, hind calypter not elongated. The bare arista would place it in *Phorbia* according to the prevailing system; but I agree with Malloch (in Trans. Amer. nt. Soc., xliv, 305, 1918) that plumosity of the arista is not a generic character in this case and *Phorbia* cannot be maintained.

NOTES ON THE BIOLOGY OF THE CARABID GENERA BRACHYNUS, GALERITA AND CHLAENIUS.*

J. L. KING, Harrisburg, Pa.

One of the most interesting and unexpected habits recorded of the *Carabidæ* centers about the egg-laying of certain species of the genus *Chlaenius*. In a family of beetles so decidedly terrestrial in their habits we are indeed surprised to find that certain members deposit their eggs in delicate mud or clay cells high above the ground on the leaves of trees and shrubs.

Dr. C. V. Riley in the Proceedings of the Entomological Society of Washington, I, 23, 1884, was the first to record this interesting method of oviposition through his observations of the egg cells of *Chlaenius impunctifrons* Say. He also stated in this note he had strong proof that *Chlaenius aestivus* Say, *Scarites subterraneus* Fab. and the genera *Dicaelus* and *Galerita* share with *C. impunctifrons* its singular mode of oviposition. However, after the publication of this note Riley does not seem to have given his proof that the beetles in question do deposit their eggs in earthen cells as does *C. impunctifrons* nor, as far as the writer is aware, do we have further mention of this anomalous method of oviposition occurring in the Carabidæ until a recent paper by Claassen in 1919.† In this paper we are given a description and figure of the mud cells of *Chlaenius impunctifrons*, the same species reared by Riley in 1884.

The writer first observed these eggs during the summer of 1917, but was not successful in rearing the larvæ which issued beyond the third instar. As all attempts to learn the identity of the cell builder proved fruitless the study was again taken up the following year with such success that it was proven *Chlaenius aestivus* Say was one of the cell builders, however, a marked difference in the form and placement of the cells led to the conclusion there were three species of cell builders living in the same habitat. Through careful rearing from eggs to adults this proved to be true as *Galerita bicolor* Drury and

* A paper on the life histories and biology of the beetles herein mentioned is in preparation by the author.

† Claassen, W. P., Life History and Biological Notes on *Chlaenius impunctifrons* Say. Annals Ent. Soc. Amer., XII, 95–99, Pl. VI. 1919.

Chlaenius impunctifrons Say were reared from the egg cells in question. After this other habitats were studied and by careful rearing of all the eggs found and obtaining eggs from beetles in captivity, it was also proven that *Chlaenius cericeus* Forst., *Chlaenius tricolor* Dej. and *Brachynus cyanipennis* Say. also deposit their eggs in mud or clay cells constructed by the female beetle.

The form, size and structure of the mud cells of these beetles seems to be distinct in each species and this, together with decided variation in the immediate location or placement of the cells, renders specific identification possible for most of the species studied with the exception of *Brachynus*.

THE MUD CELLS OF BRACHYNUS.

The mud cells of *Brachynus cyanipennis* Say (Plate XXX, Figs. 1 and 2) are somewhat crescentic or triangular in outline, rough in surface and measure about 2.25 mm. in length, that is, the longest axis. The cells of these beetles are commonly placed on the undersurface of loosely set stones, on dead twigs and plant stems; they may be placed singly or in groups of three to ten in number. In captivity the cells were sometimes constructed massed one upon the other in clusters of eighteen to twenty-five.

THE MUD CELLS OF GALERITA.

The mud cells of *Galerita bicolor* (Plate XXX, Fig. 3) are roughly triangular in outline or purse shaped and finely granular in surface. They are 5 mm. in length and 3.5 to 4 mm. in width. The cells of this species are placed singly on the under surface of smooth leaves, *Benzoin* and *Impatiens* being most frequented by the beetles in the habitat studied.

THE MUD CELLS OF CHLAENIUS.

With *Chlaenius impunctifrons*, the species studied by Riley and Claassen, the mud cells (Plate XXX, Fig. 4) are almost always smoothly convex and oblong in outline, measuring about 3.5 mm. in length and 2.28 mm. in width. In the habitats studied it was noted that about ninety per cent of the cells of this species occur on living plants, the under surface of smooth leaves being most often selected by the beetles. The distance

above the surface of the ground at which the cells are placed varies from a few inches to seven feet or higher however, one to two feet is nearer the average.

Unlike the preceding species, *Chlaenius aestivus*, while often living in the same habitat as *C. impunctifrons*, rarely ever constructs her mud or clay cells on leaves. In the habitats studied, they were found almost exclusively on dead twigs, plant stems and the bark of trees and shrubs, the dead thorns of *Gleditsia* were much used in one habitat and in another locality they were occasionally found on the strands of a barbed wire fence. They are sometimes placed ten feet above ground.

The cells of *C. aestivus* (Plate XXXI, Figs. 1 and 2) are convex and oval in form, coarsely granular or rough in surface; length 3.75 to 4.5 mm., width 2.75 to 3 mm. The exit of the larva is effected by the breaking off of the lidlike flap, which covers one side of the cell.

The earthen egg cells of *Chlaenius cericeus* (Plate XXXI, Fig 4) are smooth in surface, 3.75 mm. in length, 2 mm. in width. In general shape they are somewhat triangular or purse shaped. The cells of this species have not been observed in nature, but in captivity the beetles placed their cells on stones and the lower parts of dead plant stems, all very near the surface of the moist soil.

The cells of *Chlaenius tricolor* are small, measuring about 2 mm. in length and 1.25 mm. in width. They are strongly rounded, oblong in outline, smooth in surface and along one side there is a distinct fold or flap which marks the point of closure. This species constructs her cells of fine clay-sand. The stems of slender grasses and sedges seem to be most frequented by the beetles. Cells were found in great abundance along the shore of the Susquehanna River at Harrisburg, Pa., on the common sedge *Eleocharis tenuis*.

Construction of the Mud Cell.

As far as the writer is aware, no one has yet noted how these cells are made. This has been observed by the author, but will be only mentioned in this preliminary note, it sufficing to state that the pellet of mud is collected by the beetle at and around the tip of the abdomen in such a way that the cell formed is in reality a mold of the caudal abdominal segments;

the lid of the cell being formed from a thin layer of mud which covers the dorsal portion of these segments. After the deposition of the egg the tip of the abdomen is withdrawn and is again used to bend down the dorsal flap or lid and close the cell, the lid of which is self sealing, because of the soft texture of the mud at the time of construction. Thus the mud cells of *Chlaenius* may be compared to a pouched envelope in form and mechanism. The folding flap and the sealing of the edge when the soft mud of the flap comes in contact with the opposite lip of the cell is not different in principle from that of a common envelope. The clay cells of *Chlaenius tricolor* (Plate XXXI, Fig. 3a) show this structure quite distinctly.

As concerns the number of cells made by an individual beetle, I have noted that *C. impunctifrons* may construct seven to twenty cells during one night and eighty-two cells in a season.

Feeding Habits of the Larvæ.

The cell building habit of these Carabids presents several interesting biological questions. Among these is one relative to the feeding habits of the issuing larvæ. As concerns this, there is but a single note by Claassen, Annals of the Ent. Soc. Amer., XII, 96, 1919. I quote the following:

"Various kinds of food were offered to the young larva (*of Chlaenius impunctifrons*); larvæ and pupæ of *Lymnaecia phragmitella* Stainton, larvæ of *Nonagria oblonga* Grote, *Arsilonche albovenosa* Goeze, and *Arzama obliqua* Walk. Flies and fresh meat were also offered to the larva. At first the young larva fed somewhat on flies and on larvæ and pupæ of *L. phragmitella,* but it showed a decided preference for the little larvæ of *A. obliqua.*

During the second and third instar all other food was refused except larvæ of *A. obliqua.*

All the above mentioned Lepidoptera are inhabitants of Typha. *A. albovenosa* is an incidental surface feeder on the leaves; *L. phragmitella* lives in the heads of Typha, while *A. obliqua* and *N. oblonga* both begin their larval activities as leaf miners, later becoming solitary stem borers.

It is possible that the larvæ of *Chlaenius impunctifrons* feed altogether on the larvæ of *A. obliqua.* The former hatch

about the same time that the larvæ of the latter species leave the mines of the leaves of Typha to become stem borers. Thus while they are exposed they might easily fall prey to the Carabid larvæ."

From the above quotation it would seem that there is a possible relationship between the occurrence of the mud cells of *C. impunctifrons* on Typha and the food of the issuing larvæ as being the Lepidopterous inhabitants of Typha.

The writer believes that so far with all the known species of Carabidæ which deposit their eggs in earthen cells on plants, there is no correlation between the immediate location of the egg cells and the feeding habits of the issuing larvæ. He believes, therefore, that Claassen's statements are misleading and for *Chlaenius impunctifrons* points out the following reasons:

First, because *Chlaenius impunctifrons* is often found in abundance in habitats where Typha and its inhabitants are entirely wanting. Second, the larvæ of this species are not climbers, it being doubtful if they could climb the smooth leaves of Typha. As observed by the writer the larvæ either in captivity or in nature were never seen to climb and in their natural state have been observed at night running about among stones and debris on the muddy shores of the Susquehanna. In nature I have never observed the larvæ feeding, however, in captivity they were general feeders preying upon all soft bodied insects which were not too active to escape them. They fed greedily on small Lepidopterous larvæ (Gelechids and Geometrids) Collembola, termites, crippled flies and the larvæ and pupæ of several species of ants. The ant larvæ and pupæ were easily collected and proved an ideal food for the Carabid larvæ, consequently they were used as the chief food in rearing all the species mentioned in this paper, with the exception of Brachynus.

A further lack of such correlation between the place of egg laying and the feeding habits of the larvæ is shown in *Chlaenius aestivus* which deposits her eggs in cells on dead twigs, tree trunks and many other objects not supporting any forms of life at all. Lastly, in *Brachynus*, which genus also shares this cell building habit, we have parasitic larvæ, the hosts of which are often quite removed from the twigs, stems and stones on

which the egg cells are found. The larvæ of *Brachynus cyanipennis* mentioned in this paper, are parasitic on the pupæ of *Dineutes discolor*.

Parasites.

A number of minute Hymenopterous parasites have been reared from the egg cells of these Carabids. With *Brachynus* as high as fifty per cent of the eggs found in nature were parasitized by tiny winged and wingless Hymenoptera of the genus *Hoplogryon*. All parasites of *C. impunctifrons*, *C. aestivus*, and *C. tricolor* were winged. In one habitat studied the eggs of *C. tricolor* were parasitized to the extent of twenty-five per cent, by a minute Hymenopteron, *Prosacantha caraborum* Riley, which is a common parasite of several species of *Chlaenius*.

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The author is indebted to Mr. H. B. Kirk, entomologist, Pennsylvania Bureau of Plant Industry, who so kindly contributed his time and patience in taking the photographs herein used. He also acknowledges the kindness of Mr. A. B. Champlain, Entomologist, Pennsylvania Bureau of Plant Industry, for the verification of the species mentioned in this paper, with the exception of *Brachynus cyanipennis*, which was determined by Mr. H. C. Fall. Thanks are also due to Mr. A. B. Gahan of Washington, D. C., for the determination of the Hymenopterous egg parasites.

EXPLANATION OF PLATES.

PLATE XXX.

(Figures seven diameters.)

Fig. 1. Masses of mud cells of *Brachynus cyanipennis*. Cells made by beetles in captivity.

Fig. 2. Mud cells of *Brachynus cyanipennis* as found in nature on the under surface of a stone.

Fig. 3. Mud cell of *Galerita bicolor* on the under surface of Impatiens leaf.

Fig. 4. Mud cell of *Chlaenius impunctifrons* on under surface of Benzoin leaf.

PLATE XXXI.

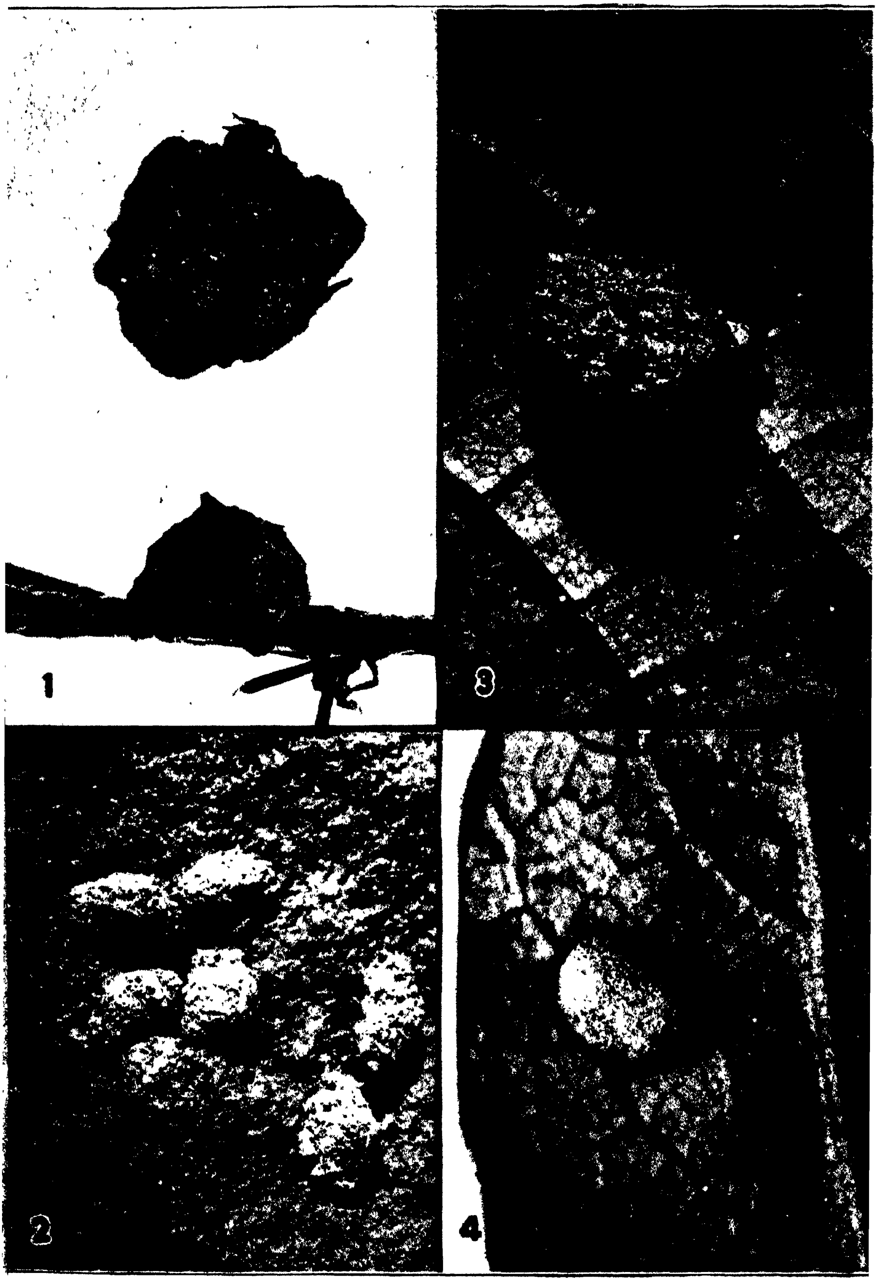
(Figures seven diameters.)

Fig. 1. Mud cells of *Chlaenius aestivus* on dead twig.

Fig. 2. Mud cells of *Chlaenius aestivus* showing lidlike opening for escape of the larva.

Fig. 3. Mud cells of *Chlaenius tricolor* on sedge, *Eleocharis tenuis*.
- a. Lateral aspect showing fold.
- b. Lateral aspect showing side opposite fold.
- c. Lateral aspect, fold removed showing egg.

Fig. 4. Mud cells of *Chlaenius cericeus*.
- a. Cell which was removed from surface of a stone.
- b. Cell on sedge.



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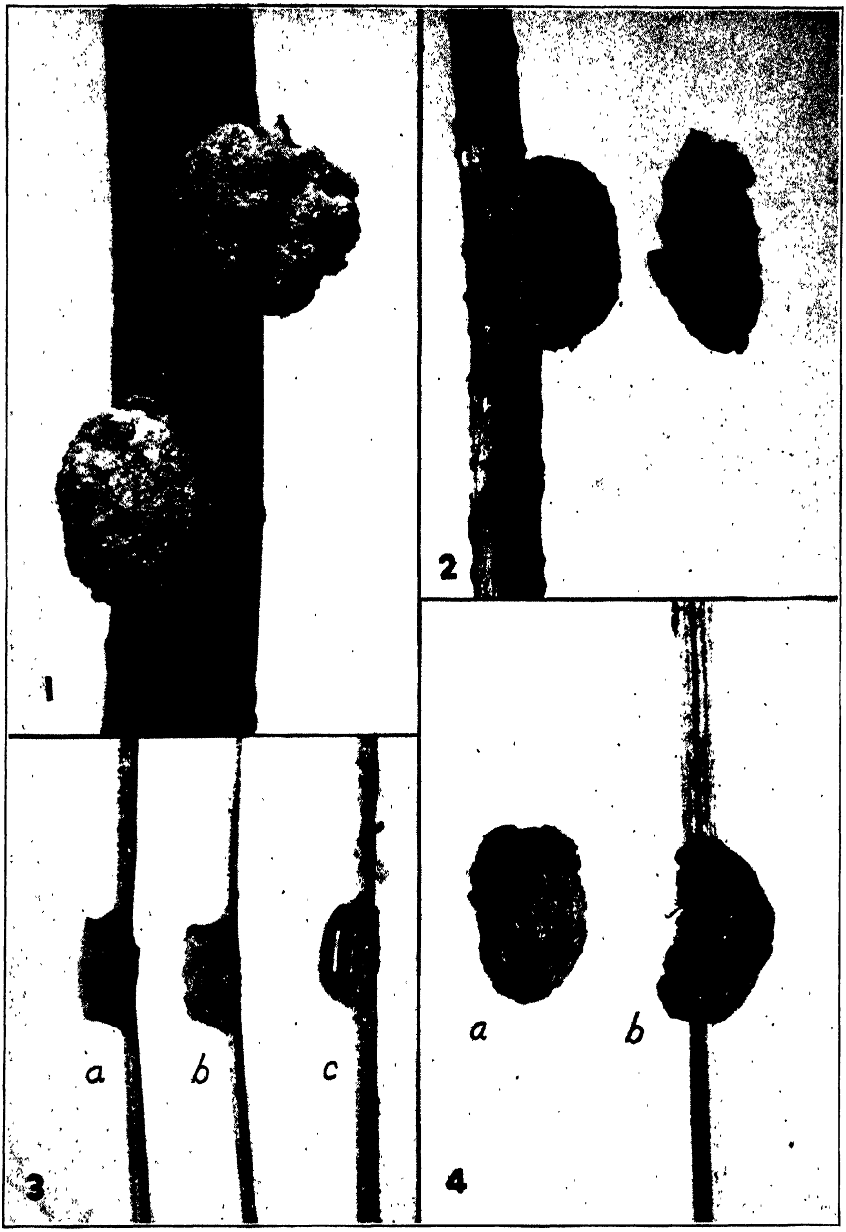

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